한국식물보호학회지 : 제22권 제 2 호
Korean J. Plant. Prot. 20(2) : 160~170(1983)

Past and Recent Situations and Prospect of the Development of Pesticides in Japan with Special References to the Prevention of Pollution

Hidetsugu Ishikura

農藥産業의 過去, 現況 및 展望—特히 公害防止—

石 倉 秀 次

INTRODUCTION

Japan is a small country having a dense population. The total territory is only 320 thousand square kilometers and agricultural land is only 5.6 million hectares for 110 million population. In other words, agricultural land per head is only 5 acres which is about one eighth of that in European countries and one fiftieth of that in the USSR.

To feed the population by this limited agricultural land, Japanese agriculture has been and is very intensive in term of production efficiency by yielding a high yield.

The weather in Japan is warm and humid in crop growing season which is favorable for the outbreak of a variety of pests and diseases of crop and also for luxuriant growth of weeds in crop fields. In order to remove these constraints so as to achieve a high agricultural production, plant protection is an important component in research and extension of Japanese agricultural technology as well as in administration.

Soon after the termination of the World War II in 1945, a series of synthetic organic pesticides, pioneered by DDT, had been introduced into plant protection in Japanese agriculture. Ever since, the number of chemical compounds employed as pesticides and their consumption had been increased tremendously as is shown in Table 1. Nowadays more than 300 chemical compounds are availed as pesticides.

Speaking on the situation of consumption in 1980, a total of 116 thousand tons of technical ingredient of pesticide was consumed. In other word, taking the area of agricultural land into consideration, each hectare of agricultural land had the input of about 21 kilograms of technical ingredient of pesticide in the said year(Table 2).

This is a very heavy burden on the environment and ecosystem unless pesticides are easily degradable in the environment and ecosystem and selectively toxic to target organisms in pest, disease and weed control.

Before we came to this finding, we had experienced a series of environmental pollution and ensuing hazards to organisms including beneficial species. This paper deals firstly with these hazards, their causes and the measures we had taken for mitigating these hazards, secondly review the trend in the development of pesticides from the viewpoint of reducing pollution and hazard, and finally foresee

The Institute of Environmental Toxicology(日本殘留農藥研究所)

Table 1. Pesticide chemicals, total sale and relative price and consumption

Year	Pesticide chemicals	Production of formulation (billion Yen)	Relative price	Relative consumption
1950	30	2.0	--	–
1960	163	24.7	100	1.0
1970	416	82.7	94	3.6
1980	330	294.6	163	7.3

the prospect in preventing the environmental pollution and ensuing hazards in future.

HISTORY OF USE OF PESTICIDES, ENVIRONMENTAL POLLUTION AND ENSUING HAZARDS

Since the introduction of synthetic organic pesticides into plant protection in Japan in late 1940s, more than three decades have passed. During this period, the consumption of pesticides in Japanese agriculture increased very much both in the number of chemical compounds employed and in the amount of formulated products as was shown already. In the early period of development in pest control, DDT and BHC were the two leading insecticides and were employed in controlling a variety of pest. Because of their low toxicity to fish, birds and wildlife in the environment, no serious hazards to these organisms were observed. The observed hazards caused by their uses were the destruction of the equilibrium existing in the pest and its parasite/predator complex since their insecticidal potency was not selective. Abnormal increases of a number of apple orchard pests such as wooly apple aphid, leafminers and leafrollers, scale insect in the citrus orchard and the green leafhopper in the rice field were observed. Many species of the red spider mite in orchards which had been of minor importance became established key pests.

Among chlorinated hydrocarbon insecticides, a number of compounds belonging to cyclodiene group, e.g. aldrin, dieldrin and endrin were released to market in 1955. Dieldrin and endrin were recommeded for the control of rice insects including the rice stem borer and the rice stem maggot. Because endrin

Table 2. Consumption of pesticide active ingredients in Japan in 1980

Category	Crp Rice	Fruits	Upland crops including vegetables	Total
Insecticide	19,580	24.746	7,321	51,647 (44.6%)
Fungicide	6,530	19,265	18,943	44,738 (38.6%)
Herbicide	12,560	624	6,314	19,498 (16.8%)
Total	38,670 (33.3%)	44,635 (38.5%)	32,598 (28.1%)	115,883 (100.0%)

(Figures in metric ton)

was highly toxic to fish, it caused a number of hazards to fish cultured in ponds neighbouring the rice fields to which endrin had been applied. The Ministry of Agriculture and Forestry accordingly directed not to use endrin in the rice field and furthermore the use of dieldrin was restricted to areas where was no risk of such a hazard. This was the first case in which the restriction was laid on the use of pesticides for preventing the pollution of environment.

Among chlorinated hydrocarbons, sodium salt of pentachlorphenol which had been tested for the eradication of water snails serving as the intermediate host of Schistosome parasite was incidentally found to be an effective herbicide in rice fields. Since the compound was known as toxic to fish and shellfish, its use as rice field herbicide was approved with the restriction that the irrigating water of the treated rice fields should not be spilled for seven days after application. However, as the use of pentachlorphenol increased, hazards to fish and shellfish were observed sporadically and in 1962, nationwide hazards were observed because of the tremendously increased use and also of a very heavy rainfall occurred at the time of application in the western part of Japan. Damages of fish and shellfish were reported not only from streams and rivers in rice growing areas but also from lakes and estuaries where the polluted water reached.

This widespread hazard to fish and shellfish drove fishery people to demand the government the legislation to ban the use of pesticides toxic to fish and shellfish for the sake of protecting fishery industry.

In 1963 an amendment was made to the Agricultural Chemicals Regulation Act and a paragraph was added to endow the local governor the power to ban or restrict the use of pesticides designated as fish-toxic in those areas where hazards to fish are liable to occur. This was the first case of the restriction on the use of pesticides was made by an Act and PCP was designated as a fish-toxic pesticide. Bofore this amendment was made, the restriction of the use of the pesticides including the prohibition of the use of endrin in rice fields was made by the administrative direction.

The restriction laid on the use of PCP promoted the research and development of fish-safe rice field herbicides and in 1963, DCPA, DBN, MCPCA and nitrofen were put into recommendation as substitutes for PCP. The restriction the use of PCP paced down the increase in consumption and PCP was gradually replaced by these fish-safe herbicides as is shown in Fig. 1.

Soon after the release of organomercuric fungicides for controlling the rice blast disease of rice in 1953, translocation of mercury from vegetative part of the rice plant to rice grain was demonstated, indicating the possible occurrence of mercury residue in the grain(9) However, toxicological significance of mercury residue was not fully understood at that time. The study of Minamata Disease which victimized many of local fishery people living in Minamata Area in the northern part of Kyushu demonstrated that the disease was caused by the intake by afflicted people of the organomercuric residue accumulated in fish which was harvested from the sea neighbouring a chemical plant. The plant had been discharging waste water containing mercury.

This finding scared the use of organomercuric compounds as fungicides and an endeavor was initiated to find substitute fungicides. Blasticidin was released as pioneer of the substitute in 1961 and this was followed by a series of organochlorine and organophosphorus fungicides effective for the rice blast disease after 1965.

In the later half of 1960s, residue of mercury in rice grain harvested from rice crop treated with organomercuric fungicides reached considerable level (11), and the administrative authority decided to withdraw organomercuric compounds from crop disease control and the withdrawal was completed in 1970.

Since the beginning of the use of organomercuric fungicides for rice blast control in 1953, a total of 2,400 tons of metalic mercury was estimated to have been released into agricultural environment until the termination of use in 1970. It was true that an extensive contamination of fish, birds and other wildlives with mercury residue was observed in the rural environment in late 1960s. However, it is difficult to identify the part played by mercury which was used for the rice blast control in the environmental pollution, because only 10 percent of total

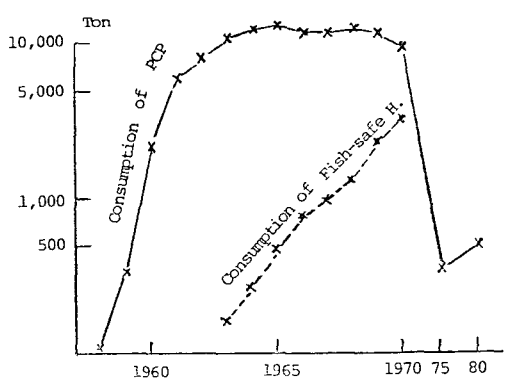

Fig. 1. *Consumption of PCP and fish-safe herbicides in rice fiields*

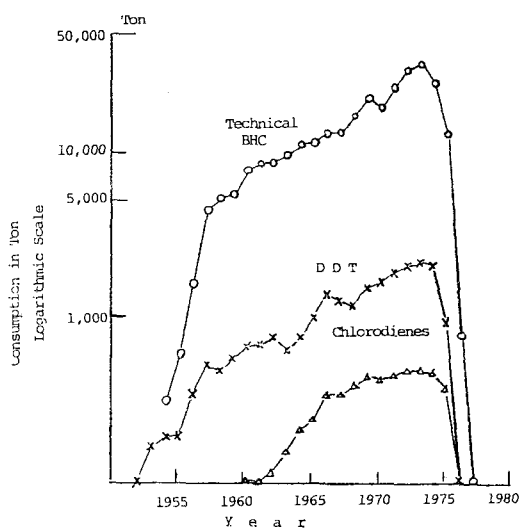

Fig. 2. *Consumption of chlorinated hydrocarbor insecticides in Japan 1952-76*

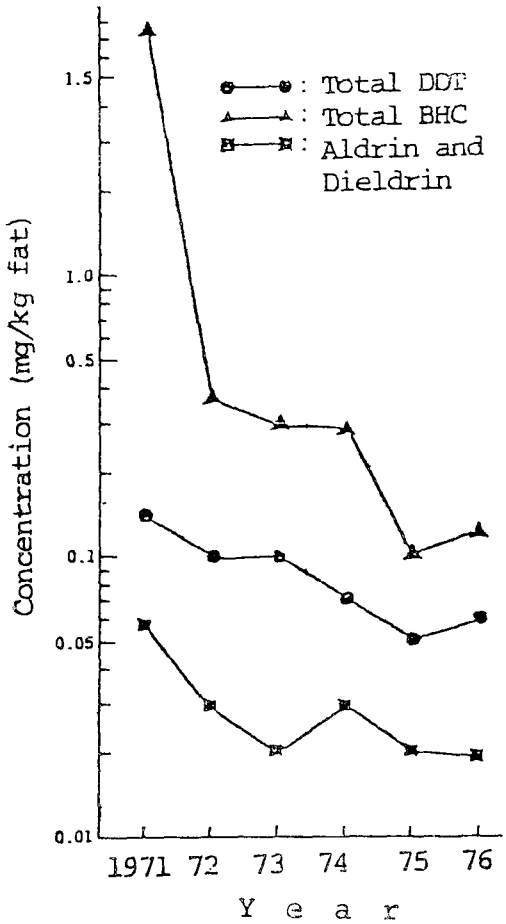

Fig. 3. Concentration of organochlorinated hydrocarbons in raw milk (Takeda, 1981)

domestic consumption of mercury was used in the production of organomercuric fungicides and considerable amount of mercury had been discharged from chemical plants directly into watermass as in the case of Minamata Disease. Furthermore, mercury deposited in rice field soil is mostly combined with sulphur in the soil to produce inert compounds.

DDT and BHC were the two major insecticides at the early stage of chemical control of many insect pests because of their wide insecticidal spectrum and persistence. Their consumption in Japan increased considerably since early 1960s. In particular, consumption of BHC had increased remarkably because granular formulation containing technical BHC in high percentage was developed and applied extensively in the rice field for the control of the rice stem borer.

In 1966, contamination of cow milk and other food commodities with the residue of BHC, in particular with beta isomer, was observed in the western part of Japan. At that time both the government and the public were so much concerned with the environmental pollution that the government took a prompt action to terminate both the production and use of these organochlorine insecticides. Both DDT and BHC disappeared from the market in 1971. The consumption of these two organochlorine insecticides from their appearance into Japanese pesticide market to their disappearance from it is shown in Fig. 2. The total ingredient was about 25 thousand tons in DDT and 250 thousand tons in BHC(2)

TREND IN LAST DECADE

The concern of the general public on the contamination of food with pesticide residues had been intensified in early 1970s and the pollution of environment and contamination of food with pesticide residues gave a strong impact on the regulation and development of pesticides.

In 1971, a great deal of amendments were made to the Agricultural Chemicals Regulation Act and the designation of crop persistent, soil persistent and water polluting pesticides was enforced. Pesticides persistent on crops such as lead arsenate, DDT, BHC and endrin were designated as crop persistent, aldrin, dieldrin, heptachlor, etc. which persist in soil and may be absorbed by a certain kinds of crop as soil persistent and PCP, telodrin, endrin. etc. which were highly toxic to fish as water polluting pesticides. These designation had actually the effects almost similar to the ban of their use and in a few years, these pesticides disappeared from the market except PCP. For the application on crops and fate in the soil became new requirements.

In the same year, Environment Agency was established and the Agency launched a comprehensive monitoring on the pollution of environment and biotic components with the residue of pesticides and other chemicals. This monitoring revealed a widespread contamination of soil, water, fish and birds with organochlorine insecticides and mercury. The monitor-

ing is still in continuation and the level of contamination is reported to have stepped down considerably but not to nil.

Since the termination of the use of DDT, BHC and other organochlorine insecticides in early 1970s, the contamination of cow milk with these insecticides decreased considerably as is shown in Fig. 3(8). However, the residue of these insecticides in cow milk has not yet reached nil. It is not clear whether the existent contamination of cow milk is caused by the residues of these insecticides in the environment or whether this contamination is attributable to the residues in imported feed.

As regards to the reduction in the contamination of enviromental biota with BHC, a very valuable data was recently reported on the residue of BHC in the fish named isaza, *Chaenogobius isaza*, inhabiting in the Lake Biwa which is surrounded by rice growing areas(10). As is shown in Fig. 4, the total residues of BHC isomers in fish body had increased in years from 1966 to 1970, almost in proportion to the increased consumption of BHC during the said period in the basin in which the lake is located. However, the amount of residue start to decrease sharply after the use of BHC in the basin was discontinued in 1970.

The large scale aerial application of fenitrothion for the control of Japanese pine sawyer, *Monochamus alternatus*, which carries pine wood nematode, *Bursaphelencus lignicolus*, in order to save the pine forest from the destruction caused by the attack of the said nematode, was launched in 1977 by the Forestry Agency under the enactment of the Pine

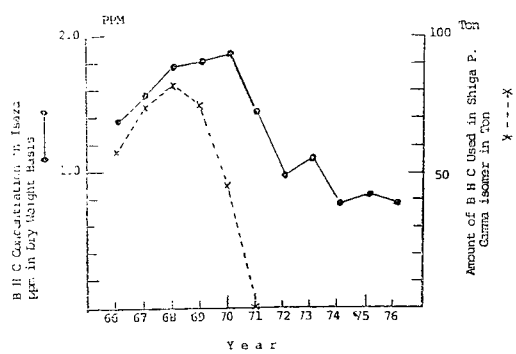

Fig. 4. Annual change of concentration of BHC residue in Isaza, *Chaenogobius isaza* and the amount of BHC used in Shiga Pref.

Tree Beetle Control Act. This operation raised the blame by the environmentalists who claimed that the aerial application of fenitrothion was not effective on the adult of Japanese pine sawyer, but it upset the biotic balance of the forest fauna and polluted forest environment. Aiming at whether such adverse effects on the environmental components were actually occurring or not by the application of fenitrothion, the Foresty Agency conducted a very comprehensive survey on the effects on insects, birds, terrestrial arthropods in the treated area and on the contamination of soil and water and its consequent effect on fish. The brief outline of the findings are as follows.

The decrease in insect population and dead insects fallen from the canopy of the forest were observed in many of the treated area soon after the application. However, the recovery of insect population was quick in many cases. No significant decrease in bird population was observed in treated area, except some cases in which the population decreased for a short period because some portion of the bird population seemed to have flown away from the treated areas. Finding of dead birds was very scarce and in most cases, case of death was not identified. Population of the terrestrial arthropod was not affected adversely except for few cases. As regards to aquatic orga-

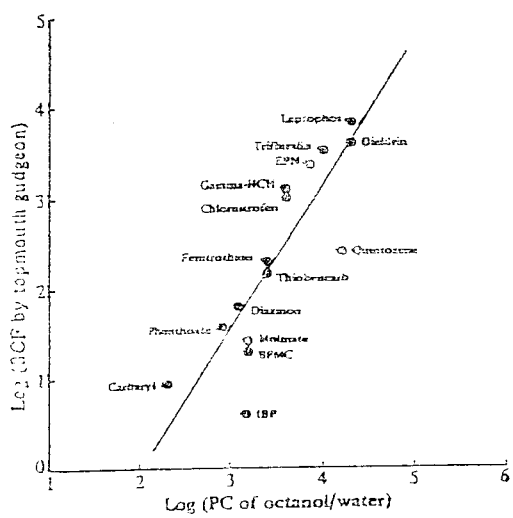

Fig. 5. Relationship between the partition coefficient (PC) for 15 pesticides and their bioconcentration factors (ECF) for topmouth gudgeon. r=0.833 (Kanazawa, 1981)

nisms, mortality of fish and the accumulation of fenitrothion in fish body was observed. However, healthy fish was also found to have been contaminated with the residue and it was difficult to conclude that the mortality of fish was caused by the pesticide applied. Population of aquatic insects and water flea was found to have decreased in many cases, but the reduction in their population was very brief.

The residue of fenitrothion on top soil became undetectable from 3 weeks to 3 months after application and the residue in water disappeared in a week after application. Therefore, it was concluded in general that the adverse effect of the large scale application, if any, was temporary and insignificant.

In fact, a series of adverse effects caused by the use of pesticides beginning with the incidence of intoxicated cases among farmers in 1950s, hazards to fish in early 1690s and the contamination of foods with pesticide residues from middle 1960s called for a comprehensive review of the use of pesticide in crop protection. To meet this demand, the concept of technology assessment was introduced for assessing both positive and negative impacts of the use of pesticuc in agriculture not only in agricultural prodidetion but also in social and ecological aspects

Table 3. Percentage of sales of pesticides as classified by toxicity

Kind	Class	1950	1960	1970	1980
Insecticide	Spebified poison	0.0	17.2	1.8	0.0
	Poison	40.0	6.9	3.6	4.2
	Deleterious subst.	30.0	44.8	70.9	37.5
	Ordinary subst.	30.0	31.0	23.6	58.3
Fungicide	Poison	25.0	5.3	0.0	0.0
	Deleterious subst.	50.0	26.3	24.1	12.5
	Ordinary subst.	25.0	68.4	75.8	87.5
Herbicide	Poison	0.0	25.0	2.4	0.0
	Deleterious subst.	0.0	12.5	4.8	8.3
	Ordinary subst.	100.0	62.5	92.8	91.6
Total	Specified poison	0.0	8.9	0.8	0.0
	Poison	33.3	8.9	2.4	1.6
	Deleterious subst.	33.3	33.9	38.0	20.3
	Ordinary subst.	33.3	48.2	58.7	78.1

of the use of pesticides(3, 4). A series of negative impacts many of which had already been referred previously in this paper were identified and the alternative technolgies for mitigating these negative impacts were sought for. As one of these technologies, development of pesticides having the property of quick degradation in the environment and leaving little residue incompatible with the environment was emphasized(5). This study led the further study on the strategy for developing safer pesticides and alproposal for the developmental procedure of such pesticides was made(6). In order to augment the capacity for assessing the safety of candidate chemicals at the developmental stage, it was considered as prerequisite to enhance research and test organizations for investing and producing toxicological data on candidate compounds. In this circumstance, the Institute of Environmental Toxicology was established in 1970.

TRENDS IN THE DEVELOPMENT OF PESTICIDES

As mentioned previously in relation to the solution of problems caused by the use of pesticides, most of the solution had only been feasible by substituting hazardous pesticides with newly developed safer and less polluting pesticides as was demonstrated in the case of hazard to fish caused by PCP and the contamination of rice grain with mercury residue. The development of safer and less polluting pesticides will be the ultimate approach to the solution of problems originating from the use of pesticides. In this context, it will be useful and suggestive to review the trend of development of pesticides in Japanese pesticide industry.

The first difficulty with which Japanese pesticide industry confronted was the safety of pesticides to farmers who engaged in the application of pesticides. High incidence of intoxication including fatal cases among farmers after the introduction of parathion in 1952 spurred the introduction and domestic development of less toxic organophosphorus insecticides. In succeeding 10 years, a number of safer orgnophosphorus insecticides were released to market. Encouraged with this development, the regulatory au-

Table 4. Number of pesticide compounds released into market as classified by fish toxicity

Pesticide	Toxicity to fish	Before 1950	1951~ 1960	1961~ 1970	1971~ 1980
Insecticide	Desingnated	1	2	2	0
	C	2	4	4	5
	B	1	14	34	16
	A	7	9	17	3
Fungicide	C	2	7	7	2
	B	4	5	14	6
	A	2	6	20	9
Herbicide	Designated	0	1	0	0
	C	0	3	3	0
	B	0	1	14	11
	A	1	5	27	14

N.B. Designated: Designated as water-polluting pesticide. Should not be used in prohibited area. Should be used according to use instruction in regulated area. C: Because of fish toxicity (TLM-48 for carp less than 0.5ppm), should not be used in those areas from which there is a possibility of drifting or spilling of pesticides into river, lake, sea and fish-culturing pond. Should not be used on large scale in other areas. B: Little effects to fish by ordinary use, but attention should be paid when used in wide areas (TLM-48 for carp 0.5~10ppm or more than 10 ppm incase LC-50 for waterflea is less than 0.5 ppm. A: No hazard by ordinary use. TLM-48 for carp more than 10ppm and LC-50 for waterflea more than 0.5ppm.

thority took the policy of discouraging the registration of highly toxic pesticides. In Japan, chemicals including pesticides are classified into four categories of specified poison, poison, deleterious substance and ordinary substance based on the acute toxicity data on rats and mice. Table 3 shows the quick decrease in the proportion of more toxic substances to the total consumption of pesticides in the past three decades. Nowadays almost all consumption of pesticides fall under the category of deleterious and ordinary substances.

The increase in the safety of pesticides to human is related to some extent to the increase in the safety of pesticides to cattle and wildlife. The hazards to cattle decreased very much in the past

Table 5. Percentage of production of pesticides in value as classified by fiish toxicity

Kind	Fish toxicity	1971	1975	1980
Insecticide	C	2.8%	3.9%	5.3%
	B	76.7	77.4	70.6
	A	21.4	18.7	24.1
Fungicide	C	21.3	12.7	14.7
	B	41.0	47.0	50.3
	A	37.7	40.3	35.0
Herbicide	C	10.6	1.3	1.4
	B	36.5	54.8	54.9
	A	52.9	43.9	43.7
Others	C	0.0	0.0	0.0
	B	0.2	1.8	0.3
	A	99.8	98.2	99.7
Total	C	9.5	5.7	6.9
	B	55.0	60.4	58.7
	A	35.5	33.9	34.3

N.B. A, B and C are as indicated in Table 4

three decades in spite of the increased consumption of pesticide in the said period.

As mentioned previously, the use of pentachlorphenol for controlling rice field weeds was restricted in 1963 and the restriction encouraged the development of fish-safe herbicides. In Japan, submission of data on the toxicity to fish and its prey, the water flea is requested upon the application of registering new pesticides. For the evaluation of fish toxicity, the fry of common carp, *Caprius caprio*, is used as test fish. Based on the toxicity data on the common carp and the water flea, pesticides are classfied into three categories and one subcategory. This is because of particular situation that almost one third of the amount of pesticides consumed in Japan is applied in irrigated rice fields and this application easily pollutes the watermass while fishery industry is very important and should be protected. Table 4 shows the number of pesticides released to market before 1950, in 1950s, 1960s and 1970s as classified by the potential toxicity to fish and water flea.

The table 4 shows that the development of pesticides

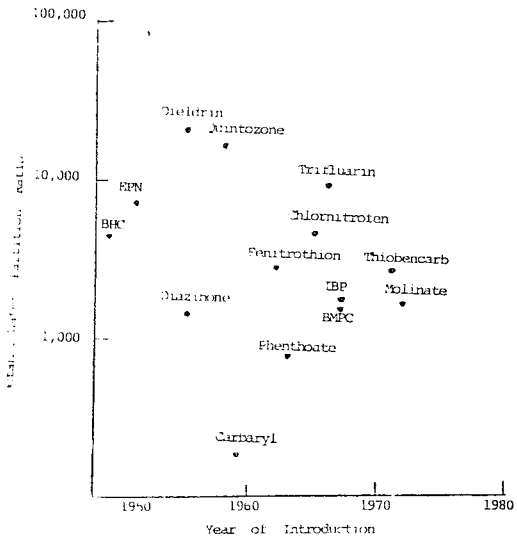

Fig. 6. Relation of Octanol/Water partition ratios of pesticides and the year of introduction of these pesticides into Japanese market.

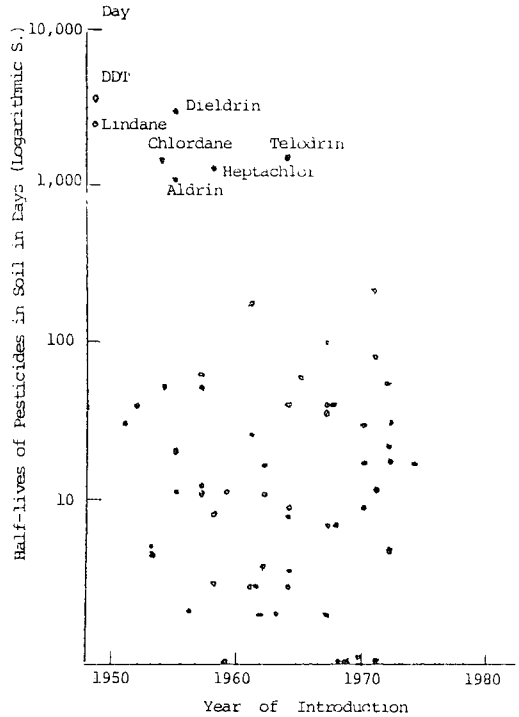

Fig. 7. Relationship of Half-lives of pesticides in soil and years of their introduction into Japanese market

safer to fish increased as the time advanced and this tendency is more conspicuous with herbicides. This is because many of herbicides are consumed in the rice field and the designation of PCP as water polluting pesticide encouraged the development of fish-safe herbicides. Table 5 shows the changes in the consumption of pesticides as classified by the toxicity to fish and water flea in 1971, 75 and 80. This table also shows that tendency of derease in the consumption of pesticides more toxic to fish seems to become inconspicuous in recent years and fish-toxic herbicides, although few in number, have been registered with the restriction in use.

As regards to contamination of food and pollution of environment with DDT, BHC and other organochlorine pesticides bioconcentration of pesticide residues in the ecosystem is a serious problem. It was demonstrated recently that octanol/water partition coefficient of the pesticide was positively correlated with the bioconcentrative property of the pesticides(7). Fig. 5 shows this correlation which was demonstrated with a species of fish, topmouth gudgeon, *Pseuporasbora parva*. Although the submission of data on octanol/water partition coefficient is not yet the requirement for registering pesticides in Japan, figures of partition coefficient are available with a number of pesticides. The relationship between these figures and the year in which respective pesticides were released into Japanese market is shown in Fig. 6. In this figure, a tendency, although not conspicuous, of reduction in octanol/water partition coefficient was observable as the year of release of pesticide into market advanced, indicating that pesticides of more recent introduction have less bioconcentrability in the ecosystem.

It is well known that many of pesticides are degraded in soil primarily by the activities of soil microorganisms. One of the reason why DDT and other chlorinated hydrocarbon pesticides contaminated the ecosystem so comprehensively was their poor degradability in soil. Their half-lives in soil were counted in the order of years. Therefore, in the development of environmentally safe pesticides, rate of degradation in soil is a criterion for estimating potential hazards in the environment. The recent registration of new pesticides in Japan request the submission of data on the degradability of pesticides

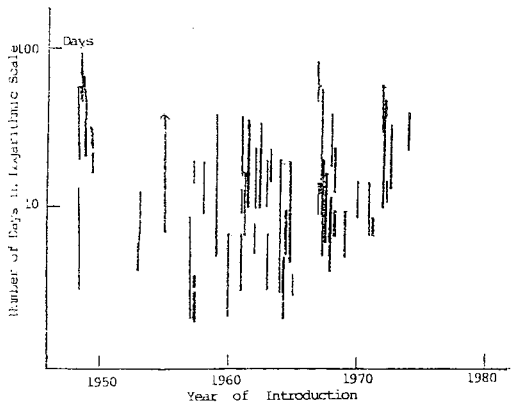

Fig. 8. Relationship of the number of days in which residue of pesticides becomes intoxic to silkworm and the years of introduction of these pesticides into Japanese market

in soil including half life in connection with the designation of soil-persistent pesticides.

Fig. 7 shows the relationship of the half lives of various pesticides in soil under dry field condition and the year of their introductions into Japanese market. The data on half lives of pesticides is after Annoymous(1). It is rather clear from this figure that pesticides introduced more recently have shorter lives in soil in general, indicating that they may cause less pollution in the ecosystem.

As a specific problem related to the environmental contamination by pesticide residues in Japanese agriculture is the protection of silkworm from the damage caused by the residues of pesticides, in particular of insecticides, on mulberry leaves. Since the size of crop fields in Japan is small and mulberry fields are located side by side with fields planted to other crops which require the application of pesticides, mulberry leaves collected from these fields are liable to be contaminated with pesticide drift from nearby fields and the damage of silkworm and consequent poor harvest of cocoons are frequently reported.

It may be very difficult to develp insecticides which are selectively safe to silkworm and effective to pest species. Fig. 8 shows the relationship of the number of days on which mulberry leaves contaminated with insecticide residues applied at conventional dosages become safe to silkworm and the year of introduction of these insecticides into Japanese market. The relationship seems to be very much confusing, and it should be concluded that the development of insecticides so far achieved fails to show selective safety to silkworm.

PROBLEMS REMAINED

Although a series of adverse effects to human being, environment and ecosystem have been mitigated in recent years by switching hazardous pesticides to newly developed safer pesticides, there still remains some problems which call for the further solution in order to make the use of pesticides more contributable to the crop protection in Japan.

The issue of the utmost importance is the need for more detailed evaluation of the safety of pesticides already existing in Japanese pesticide market and the dissemination of more persuasive informations on the safety of pesticides among public. Public still has a deep concern on the residues of pesticides and their toxicological significance to human being. The technology for evaluating the toxicological effects of pesticides is in a rapid progress. Some of the safety data produced in old days by less sophisticated testing methods may be needed to be reevaluated by advanced testing procedures. For example, use of DBCP was recently cancelled by the finding of adverse effects on spermatogenesis by advanced methods. In order to make the study in safety on an comprehensive scale and in more detail by advanced testing procedures feasible so as to produce safety data more persuasive to public, intensification of research and testing facilities and training of personnel are most required.

The destruction of pests and their parasite/predator complexes by the application of nonselective synthetic insecticides such as DDT, BHC and parathion suggests that future insecticides should be selective in toxicity to pests and their parasite and predator complexes. In other words, future insecticides should be compatible with what is called as integrated pest management.

The insecticidal specificity is most remarkably exemplified in microorganismic insecticides. Insect pheromones, which are not insecticidal in true

meaning, could be utilized for suppressing pest population in the field and disturbing their reproduction behavior in the field. Outlook on the development of microorganismic insecticides is not so bright because biotic agents available are rather limited and their efficacy is much affected by environmental condition. Technology for isolation, identification and synthesis of insect pheromones has been much advanced thanks to the development of methodologies and instruments of chemistry. However, much studies have to be conducted under field condition as to the method of application including the density of sites for releasing pheromones. The present art of technology for utilizing insect pheromones in crop protection is limited to the assessment of pest population in the field for prediction purpose.

Since the regulation on safety of pesticides was intensified by adding the amendments to the Agricultal Chemicals Regulation Act in 1971, some 70 pesticides disappeared from Japanese pesticide market. As the result, control of a considerable number of insect pests and diseases became very difficult because of the absence of effective pesticides. Control of soil insect pests and disease became particularly poor due to the regulation on soil-persistent pesticides. It will be a contradiction in future development of pesticides, while the protection of the environment and ecosystem calls for less persistence in the environment, efficacy for control of pests and diseases, particularly in soil, demand the long persistence of the pesticides. The solution for this contradiction may be in two ways, the search for selective toxicity to target and non-target organisms and the compromise of risk and benefit of the use of pesticides. It is a difficuty that some people do not agree with this compromise.

In order to encourage the Japanese pesticide industry for developing new pesticides effective to pests and diseases which are at the moment difficult to control, the Ministry of Agriculture, Foresty and Fisheries created a fund in the Institute of Environmental Toxicology to partly support the expenditure required for toxicological test of candidate products for control of these pests and diseases.

Since more than one third of the total consumption of pesticides in Japan is used in the rice field, the protection of aquatic environment and the fishery will remain as an issue of high priority in the future as well. Recently, marine fish culture is a growing industry in coastal area of the country and protection of this industry from effluents from agricultural area, in particular from rice growing area, is posing a new problem. Both the Ministry of Agriculture, Forestry and Fisheries and Environmental Agency are now implementing programs on the safety of pesticides to marine fish by contracting the studies to the Institute of Environmental Toxicology and several prefectural fisheries stations.

Japanese agriculture is now confronted with two difficulties. One is the domestic overproduction of a series of agricultural commodities at high production cost which is most clearly exemplified in the price of rice and another is the strong pressure from foreign countries for the liberalization of importation of agricultural commodities produced at much cheaper cost. Under these circumstances, and in order to let Japanese agriculture survive on the competition with foreign agriculture, economization of agricultural production is a must in the development of agricultural technology and administration. The cost for crop protection also should be economized by reducing the input of pesticides into agricultural production by the development of more efficient pattern of use, hopefully in an integrated manner with other methods of control. If the reduction in the input of pesticides is achieved in this way, it will contribute to the further solution of environmental problems associated with the use of pesticides.

LITERATURE CITED

1. Annoymous. 1976 Persistence of Pesticides in Soil and their Safety. Shokubo Comment. No. 24 : 1 ~5
2. Inouye, K. 1978. Rise and Decline of the Production of Organo-mercuric fungicides, DDT, BHC and parathion. Nippon Shokubutsu Boeki Kyokai Sp. Publ. 48 pp.
3. Ishikura, H. 1973 Checking Pesticide Use Technology and Future Problems. A Case Study for Technology Assessment. Shokubutsu Boeki, 27 : 15~21

4. _ _. 1973. Technology Assessment on the Use of Pesticides. Proc. Third Int. Symp. Chemical and Toxicological also Env. Quality and Safety 1 : 25～35
5. ___. 1974. Technology for Developing Safer Pesticides. Shokubutsu Boeki. 28 : 31～36.
6. ___. 1975 Strategy for Developing Safer Pesticides and the proposal on Developmental Procedures. Shokubutsu Boeki. 29 : 27～32
7. Kanazawa, J. 1981. Measurement of the Bioconcentration Factors of Pesticides by Freshwater Fish and their Correlation with Physicochemical Properties of Acute Toxicity. Pestic. Sci. 12 : 417～24
8. Takeda, M. 1981. Recent Status of Pesticide Residue Monitoring in Japan. Shokubutsu Boeki. 35 : 57～63
9. Tomizawa, C. 1957. Absorption of phenyl mercuric Acetate in Rice Plant. Annals Phytopath. Soc. Japan, 22 : 45
10. Watanabe, N. et al. 1981. Pursuit of Residue of Organochlorine Pesticides in Freshwater Fish, Isaza (*Chaenogobius isaza*, Tanaka) Journ. Pestic. Sci. 6 : 31～36
11. Yamada, T. 1970. Studies on Residual Organomercuries in Plants. Bull. Nat. Inst. Agric. Sci. C. No. 24 : 165～210