PESTICIDE RESIDUE PROBLEMS IN KOREA

Young-Ho JEONG*

Abstract

The present status of pesticide residue problems in Korea is described, including monitoring activities, residue levels in agricultural products and safe use of pesticides. As cultural practices in agriculture have been intensively developed during the last two decades, the use of pesticides is becoming essential for securing a reliable output in agricultural production. Most pesticides used in Korea belong to the less persistent types, even though a few chemicals including organochlorinated compounds are still being consumed in smaller amounts.

Results of monitoring surveys on pesticide residues in agricultural products, soil and irrigation water which have been conducted by the government institutions since 1968, show quite low or trace levels as compared to the MRLs set up by FAO/WHO.

A close cooperation among government organizations, pesticide manufacturers and farmers is being promoted so as to utilize the pesticides effectively and properly.

Introduction

Agricultural practices in the last ten years have improved markedly to meet self-sufficiency in national food demand. The Korean government in particular has striven to increase rice yield by the development and dissemination of high-yielding varieties, heavy application of fertilizers and high planting density as well as early transplanting. These advanced techniques, however, have resulted in the changing pattern and outbreaks of major diseases and insect pests (Fig. 1). Since

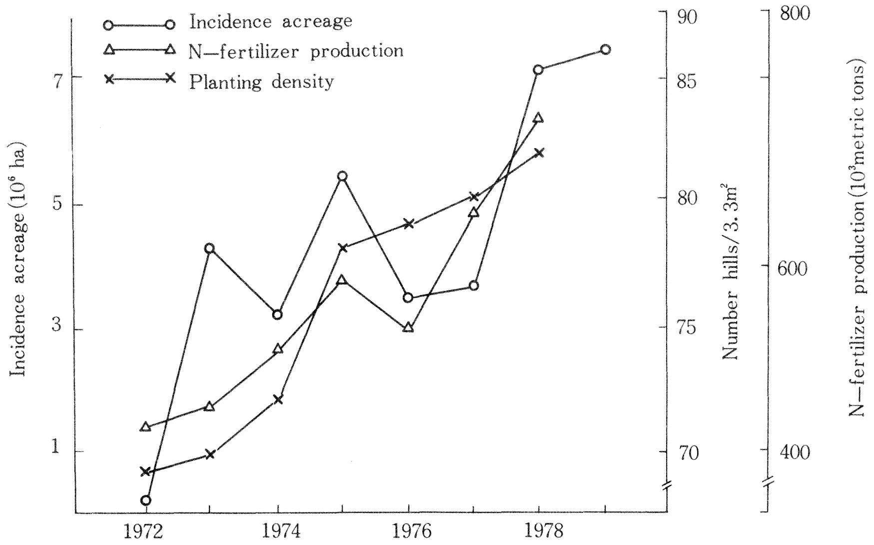


Fig. 1 **Annual changes in planting density of rice, amounts of N-fertilizer production, and incidence area of diseases and insect pests.**

* Department of Pesticide Chemistry, Agricultural Chemicals Research Institute, Suweon 170, Korea.

pesticides are an essential component for agricultural production, their consumption has increased greatly during the last two decades even though there were some annual fluctuations due to the incidence of diseases and insect pests.

In accordance with the increased consumption of pesticides, several adverse effects on the agricultural community and environment have been a cause of social concern, including acute poisoning due to the handling and application of toxic chemicals, and chronic risks from a long exposure to or ingestion of minute amounts of the residues in foods.

The government has consequently given special priority to implement safe, efficient and economical use of pesticides from the beginning of the manufacture to the final utilization and disposal of the products.

This paper will cover the present status of pesticides in Korea along with their safe use including monitoring activities of chemical residues.

Consumption pattern of pesticides

With the increase of the outbreaks of diseases and insect pests annual consumption of pesticides has also notably increased in the last two decades as shown in Fig. 2.

Consumption of fungicides decreased from 1972 to 1976 due to the cultivation of Tongil varieties of rice which were resistant to rice blast. However, as the new high-yielding varieties are becoming susceptible to blast, the use of fungicides has increased rapidly since 1978. Consumption of herbicides has also increased continuously because of labor shortage and higher wages in the rural community as a result of industrialization. On the other hand, insecticide use has decreased

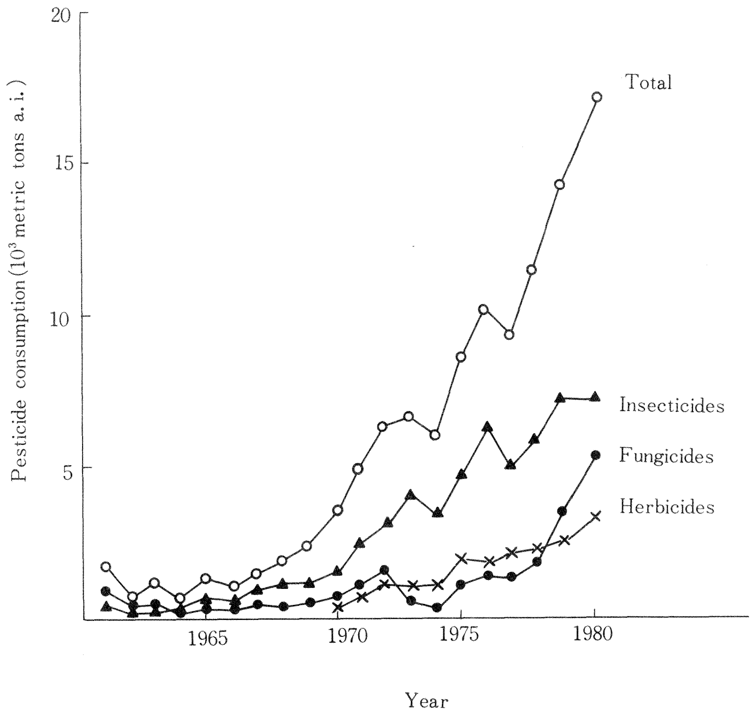


Fig. 2 Annual consumption of pesticides.

to 38% of the total consumption of pesticides during the last decade.

A typical transition in pesticide consumption with regard to formulations was also observed even in the short period covering the last five years. Consumption of dust formulations in general has declined, while that of the other formulations is still increasing. Even though granular formulations are comparatively expensive due to the high cost of active ingredients included per unit area, farmers prefer this type of formulation because of ease of handling and application (Table 1).

Table 1 Annual consumption of different formulations (metric tons a.i.) of pesticides.

Formulation	1976	1977	1978	1979	1980
Emulsifiable concentrate	3,079	3,142	4,125	4,823	4,868
Wettable powder	2,329	1,914	2,164	2,494	3,731
Soluble powder	254	364	536	696	495
Dust	1,358	810	1,355	1,497	701
Granule	3,233	2,815	2,894	4,495	5,314
Others	83	73	253	448	1,022
Total	10,336	9,118	11,327	14,453	16,131

Prohibition of persistent pesticides

Persistence of a pesticide for a certain period of time is sometimes desirable and has been recognized as a prerequisite in some instances for successful control of harmful organisms. However, chemical toxicity arising from very small amounts of pesticide residues in food and in the environment has become an important problem for the overall risk/benefit evaluation. As a rule, in the early stage of plant protection the efficacy of a pesticide used to be the most important consideration. Likewise in the other countries, organomercurials and organochlorinated compounds as major pesticides have been sprayed for a long period of time in the early stage of plant protection because of low cost and availability of pesticides.

With the growing awareness of the contamination with heavy metals and organochlorinated compounds of the mammalian tissues and biosphere, the government prohibited the production of organomercurials on the basis of survey results on mercury content in brown rice. The use of these pesticides was restricted to seed disinfection in 1971. Thereafter, the use of Uspulun containing phenyl mercury acetate as a unique seed disinfectant was permitted until 1977, when newly developed chemicals were developed following thorough and strict trials.

In addition, the manufacture and use of DDT and other cyclodiene compounds were banned in 1973. Application of BHC was limited to forest protection and the control of the first emergence of the striped rice borer was achieved only with the use of purified r-isomers until 1979. Consequently, the annual consumption of organochlorinated pesticides decreased in 1980, although some O/chlorinated pesticides such as endosulfan, toxaphene, discofol, fthalide, etc. (Fig. 3) were available.

Pesticide Management Law in Korea which has been recently revised classifies persistent pesticides into three categories, as follows: crop-persistent, soil-persistent and water-pollutant pesticides, respectively. The law prescribes that residue data relating to crops and soil persistence of a pesticide should be notified to the government for registration.

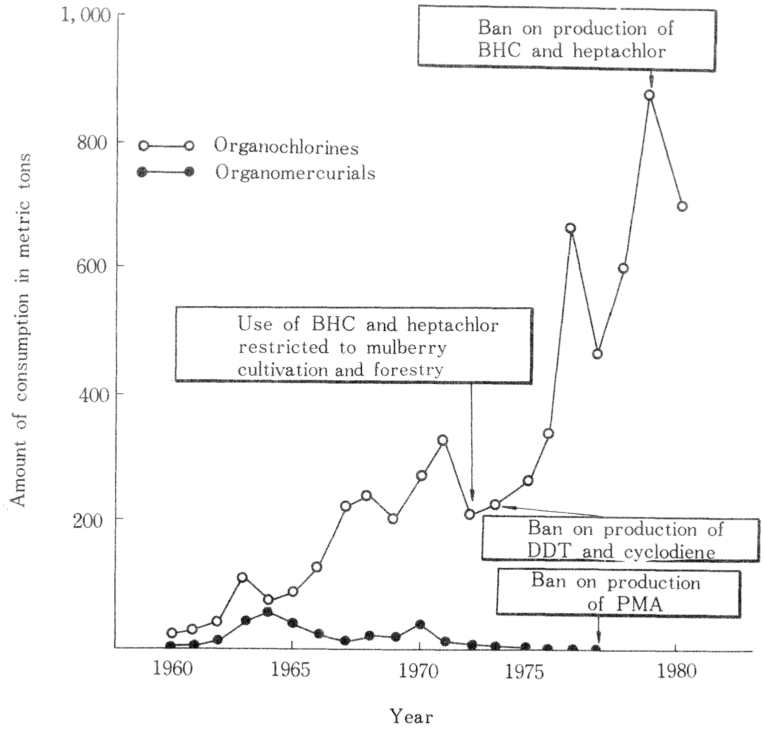


Fig. 3 Annual consumption of organomercurials and organochlorines.

Organizations for monitoring surveys on pesticide residues

The following governmental organizations are responsible for conducting monitoring and supervised trials on pesticide residues: the Agricultural Chemicals Research Institute (ACRI), the National Institute of Health (NIH) and Office of Environment (OE). ACRI is responsible for the organization of supervised trials on the efficacy, acute toxicity and residue studies of pesticides for domestic registration. The Institute also carries out nationwide monitoring surveys to obtain information on the current status of pesticide residue levels in agricultural products collected from fields.

Monitoring of pesticide residues by NIH and OE is undertaken at market places to assess consumer intake through dietary studies from time to time.

Monitoring of pesticide residues in agricultural commodities at farmers' level

Monitoring of pesticide residues in agricultural products sampled from the fields was first initiated in 1968 by the Office of Rural Development. Mercury contents were determined in brown rice. Since then, this activity has been conducted to investigate the level of pesticide residues in agricultural products collected from the fields. The samples covered so far include cereal grains, fruits, vegetables, soil and irrigation water (Table 2).

Table 2 Monitoring surveys on pesticide residues in agricultural commodities.

Year	No. of samples	Agricultural commodity
1968	266	Hulled rice
1972	57	Strawberry, Mushroom
1973	44	Cucumber, Lettuce
1974	135	Tomato, Strawberry, Lettuce, Apple, Pear, Citrus
1975	342	Hulled rice
1976	316	Apple, Peach
1977	236	Hulled rice, Soil, Irrigation water
1979	402	Hulled rice, Soil, Grape, Cabbage
1980	300	Hulled rice
1981	450	Cucumber, Strawberry, Tomato

These investigations on pesticide residues led to the following conclusion: "high levels of pesticide residues in agricultural products are seldom observed". In particular, maximum level of residues of a certain pesticide in some crops seldom approaches the values of the MRLs established by FAO/WHO (Table 3). In this case, the residue data have been communicated to the related farmers through feed-back channel by agricultural extension workers, who supervise the execution of appropriate application measures. At the same time, samples from the fields are being continuously analysed for the residue levels as time goes by. Supervised trials for the establishment of spray standards with regard to intervals and frequency are carried out by ACRI.

Table 3 Pesticide residues in and on hulled rice.

Pesticide	1975 (342 samples)		1979 (85 samples)	
	Frequency %	Average ppm	Frequency %	Average ppm
I B P	–	–	38	0.001
Edifenphos	3	t	5	0.004
Diazinon	55	0.001	2	0.001
Fenthion	8	0.001	0	ND
Fenitrothion	10	0.003	4	t

Present problems of pesticide residues

The residues can be classified into the following two groups:

1) short-term residues resulting from the use of less persistent, though often highly toxic compounds such as organophosphates and carbamates,
2) long-term residues which may persist in the environment and accumulate in certain organisms.

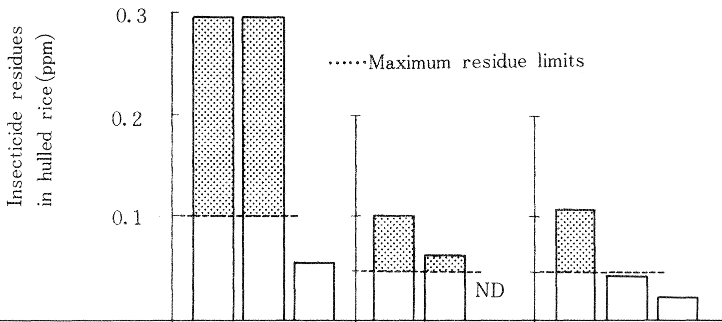
Most of the pesticides are of such low persistency and toxicity that there is little concern about their residue hazards. These include the majority of herbicides and fungicides. Although most of these pesticides are not usually included in monitoring surveys, pesticide chemists must be aware of their properties and potential hazards. In certain cases, further studies may be required. It is, however, difficult to conduct monitoring surveys on all the pesticides in developing countries because of the scarcity of analytical instruments, budget, techniques, etc.

Analytical methods of pesticide residues follow the AOAC, FDA manuals and related references. The methods vary from country to country even though pesticides may be identical in the same sample. And the different methods may create large variations in the results, which are difficult to compare. Consequently, it is urgently needed to establish a standardization of analytical methods for pesticide residues along the lines of the International Standard Methods.

Extablishment of standards for intervals and frequency of pesticide sprays

Regulations on pesticide residues in agricultural products after harvest involve shortcomings because the level of residues is gradually decreasing with time and most of the agricultural products are consumed after processing. Furthermore, it is almost impossible to remove foodstuffs highly contaminated with pesticides from the market before distribution because of the time required to analyse sampled materials.

Therefore, it is desirable that pesticide applications abide by the spray standards for intervals and frequency from the viewpoint of good agricultural practices. For these reasons, ACRI has placed special emphasis on the establishment of the standards. In the case of paddy rice, insecticides should be applied at scheduled intervals and frequency before harvest. On the basis of the results of residue levels in and on harvested brown rice, standards for safe use of insecticides on paddy rice could be tabulated (Fig. 4, Table 4).



Days of spraying before harvest	7, 15	7, 30	15, 30	7	15	30	3, 7, 15	3, 15, 30	7, 15, 30
No. of sprays	4			3			5		
Insecticide	diazinon			fenthion			phenthoate		

Fig. 4 Insecticide residues in hulled rice treated with different spray schedules. No. of applications including 2 applications for control of striped rice borer.

Table 4 Standards for safe use of pesticides for rice.

Pesticide	Formulation	Days from last spray to harvest	No. of sprays
Diazinon	34.0% EC	15	4
Fenthion	50.0% EC	30	3
Phenthoate	47.5% EC	15	5

Since trials on paddy rice were carried out in 1977, standards of 90 formulations for 25 crops have been established up to 1982. On the basis of the standards, 19 formulations for 11 crops were derived from the supervised trials undertaken by the government institutions and the others from foreign references. The Pesticide Management Law prescribes labelling of pesticide containers with the established standards.

It is suggested that several factors which influence the residue levels in and on the edible portions of crops, be carefully considered for the establishment of standards. These factors involve regional differences related to climatic conditions, and cultural practices, as well as various formulations of pesticides.

Conclusion

With the progress of science and technology in various fields and increase of public awareness of the hazards of pesticide residues, requirements for national registration have increased and become more sophisticated worldwide. As far as the quality of the registered pesticides is concerned, there are no urgent problems to solve because considerable safety margins are being included in the regulations. No matter how well-framed a regulation is, it becomes meaningless, due to careless, inappropriate and indiscriminate use of pesticides by farmers. From this view-point, education and training of the farmers are fundamental ingredients for sound pesticide management. Since farmers in general have insufficient information and knowledge on the safe and efficient use of pesticides, agricultural personnel who are responsible for pesticide applications should continuously ensure that pesticides are used in a sensible manner. Like other useful products of man's creativity such as automobiles, atomic power, etc., pesticides are extremely beneficial to human beings provided they are correctly and properly utilized.

Discussion

Ishikura, H. (Japan): What method did you employ to assess consumer intake of pesticide residues? Is it the market-basket method or total diet studies?

Answer: We employ the market-basket method.

Ishikura, H. (Japan): Comment: At our Institute we are also studying the fate of pesticides in the course of cooking. We found that the amount of pesticide residues decreases after cooking and that the assessment values of residues compared with actual consumer intake is higher if the market-basket method is employed.

Obien, S.R. (The Philippines): In one of the tables you showed the standards of pesticide safety in rice for several compounds, such as diazinon, etc. What is the rate of application per hectare for these compounds?

Answer: Diazinon (34.0% E.C): 1.6 l/ha
Fenthion (50% E.C.): 1.6 l/ha (Standard amount at the flowering stage of rice)
Phenthoate (47.5% E.C.): 1.6 l/ha

Yang, C.Y. (AVRDC): Could it happen that the toxicity of the residues might increase as a result of food processing, in particular when high temperatures are applied during cooking?

Answer: **Hulpke, H.** (Federal Republic of Germany): We have conducted several studies to compare the two types of determination of residues, namely market-basket and total diet investigations so as to gain information on the fate of pesticide residues during food processing. Seven organochlorine, 15 organophosphorus and 15 other chemical classes were investigated. As a rule, food processing (cooking, boiling, cleaning, removal of the non edible parts) induced a decrease in the amount of residues (10% on the average). In particular, we found that the market-basket studies showed 9 to 10 times higher residue levels than the total diet studies. We also observed that the conversion products of the pesticide residues during food processing are identical with those recovered in studies of metabolism or in abiotic degradation. During food processing the temperatures are usually below 400°C. However, it is possible that different products may be generated if the temperatures exceed 450 – 750°C. Therefore, under ordinary conditions of food processing it appears unlikely that the toxicity of the residues would increase.

Magallona, E.D. (The Philippines): In the market-basket studies which you mentioned, how were the pesticides identified?

Answer: I cannot answer your question because the Agricultural Chemicals Research Institute does not monitor pesticide residues in agricultural products. On the other hand, the National Institute of Health and the Office of Environment are responsible for monitoring pesticide residues.