Environmental Toxicology of Pesticides

edited by Fumio Matsumura · G. Mallory Boush · Tomomasa Misato

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PREFACE

The need for an academic discipline to cover the area of pesticide toxicology in relation to the environment is apparent. What is not so apparent, however, is the scope of such a discipline, as well as the areas of study or approaches involved. No doubt gradual evolution will settle this matter as it so often has in the past, for many fields have developed somewhat spontaneously through the needs and interests of society. However, we intend to bypass this enigma at the present by assuming that all scientists who are interested in problems of environmental contamination by pesticidal chemicals are "environmental toxicologists."

This treatise developed as a result of a United States-Japan seminar on "Environmental Toxicology of Pesticides" held in Oiso, Japan, in October, 1971. The purpose of the seminar was to discuss and exchange ideas and technology on the problems associated with pesticidal contamination in these two countries.

The problems of environmental contamination are the result mainly of modern industrialization, urbanization, and highly developed agricultural practices. It is not surprising, therefore, that such problems would be especially acute in the United States and Japan. Upon examination of the past use of pesticides in these two countries, several intriguing differences are noted, particularly with regard to the way problems have arisen and were subsequently treated. The scientific communities of both nations have also taken different paths, due partly to the differences in public demands as well as historical and geographical factors, and partly to historical differences in approach to problem-solving.

The major concern in the United States has been with pesticide residues in food for human consumption, as well as mammalian toxicities of pesticidal compounds. Only recently has serious attention been focused on other problem areas such as effects on wildlife, water quality, and environmental alteration of pesticides. Particular emphasis has been placed on the chlorinated hydrocarbons, with DDT singled out as the principal target of public and scientific concern.

In Japan, the major concern has been on development and study of chemicals for rice production, including insecticides, herbicides, and fungicides for rice-blast control. Organomercurials, used in controlling rice blast, have

been the major factor in increasing rice yields. In addition, they have created severe environmental problems. As a result, studies on the effects of organomercurials on higher animals as well as their behavior in the environment have been in progress in Japan for many years. In addition, the widespread use of BHC for control of the rice stem borer created problems somewhat similar to those caused by DDT in the United States. Interestingly, Japan has been quick to suspend the use of these chemicals, and her scientists have been highly successful in developing alternative means, such as the use of biological control, antibiotics, and other chemicals with less undesirable properties for pest control.

The intended purpose of this book is to report the present state of knowledge in the major pesticidal subject areas and to describe the efforts and approaches underway in solving or understanding these problems. This is particularly helpful to those of us with English as our primary language as many of the studies of our Japanese colleagues have been previously reported in Japanese. It is apparent that this book is the compilation of individual work, and thus its strength, or weakness, depends upon the individual contribution.

Pollution is a global problem, and, as such, exchange of ideas and data among scientists from different countries and disciplines should certainly help all of us. With the interests shown by people today on the subject matter of environmental pollution, we hope that publication of this book does not need further justification.

The seminar was financed by the National Science Foundation and the Japan Society for Promotion of Science. We extend our thanks to both for their support and cooperation in making the seminar possible.

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G. Mallory Boush
Tomomasa Misato

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PART I

INTRODUCTION: PATTERNS OF PESTICIDE USAGE AND OCCURRENCE OF RESIDUES

IMPACT OF PESTICIDE USE ON THE JAPANESE ENVIRONMENT

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Introduction

The consumption of pesticides by Japanese agriculture has increased tremendously during the past two decades. The Report on the World Food Problem prepared for the U.S. President by his Office stated that Japan had consumed 10.8 kilograms of pesticides, in terms of active ingredients per hectare, in 1963. Goto (1970) estimated that a comparable figure for 1967 would be 12.0 kilograms.

The consumption of pesticides at such a high level in Japanese agriculture seems to have been brought about by some characteristics of Japanese agriculture. The territory of Japan is only 370,000 square kilometers, which is about 10% smaller than the state of California. In addition to this small territory, the four major islands of Honshu, Shikoku, Kyushu, and Hokkaido are mostly mountainous and only 16% of the land area is arable. The actual

cultivated area amounts to only 5.8 million hectares, and as such the circumstance dictates a heavy use of agricultural lands.

In addition, these agricultural fields of 5.8 million hectares are divided into 5.2 million farms. Many farms are small in size, usually less than one-tenth of a hectare. The total areas of cultivation for several major crops in Japan are summarized in TABLE 1.

To increase the yield of crops per unit area, farmers have been relying heavily on chemical fertilizers for some time. The consumption of chemical fertilizers increased strikingly after World War II along with the restoration and expansion of the manufacturing capacity. As of 1967 the total domestic consumption of fertilizer was estimated to have reached 889,000 tons for nitrogenous material (on nitrogen basis), 671,000 tons for phosphates (on P_2O_5 basis), and 651,000 tons for potash (on K_2O basis). As is shown in TABLE 2, these figures mean a 50, 73, and 68% increase over the 10-year span for nitrogen, P_2O_5, and K_2O consumption, respectively.

The increased use of fertilizers along with adoption of denser spacing methods for cultivating more plants per unit area brought vigorous growth for many crops which made these crops more vulnerable to pest infestation.

The Japanese Archipelago stretches south to north between 28 and 45 north latitudes and is located in the Pacific Ocean off the Asian Continent. Because of this geographical location, climate varies considerably by the district and by season. Summer temperatures are high enough, particularly in the southern half of the country, for growing crops of tropical origin such as rice, oranges, and tea. Rice is grown even in the northern part of Hokkaido under intensive cultural managements. High summer temperatures, along with high humidity, are favorable for fungal and bacterial growth on many crops. The levels of annual precipitation range from around 1,000 milimeters in the eastern part of Hokkaido and in the Seto Inland Sea area to more than 3,000 milimeters in several Pacific coastal areas of Kyushu, Shikoku, and Honshu. Most of

TABLE 1

Planted Area[a] of Major Crops Exceeding 10,000 Hectares

Crop	Area	Crop	Area
Irrigated rice	3,173	Pumpkin	17
Dry field rice	101	Egg plant	27
Wheat	322	Tomato	20
Barley		Strawberry	13
(husked and naked)	316	Cabbage	45
Oat	41	Chinese cabbage	49
Corn	18	Leaf crucifers	23
Potato	169	Spinach	24
Sweet potato	154	Stone leek	28
Soy bean	103	Head onion	33
Kidney bean	68	Radish	87
Peanut	59	Carrot	25
Azuki bean	100	Burdock	18
Buckwheat	23	Dasheen	37
		Garden pea	15
Oranges	188	Kidney bean	
Grapes	23	(vegetable use)	12
Apple	61	Sweet corn	24
Peach	21		
Japanese apricot	16	Oil rape	30
Japanese pear	18	Tea	50
Persimmon	37	Tobacco	75
Chestnut	38	Sugar beet	55
		Sugar cane	13
Cucumber	32	Konnyaku	17
Watermelon	39	Mulberry	162

[a]Data taken in 1968 and expressed in 1,000 hectares.

the precipitation occurs in June, July, and September on the Pacific Coast, frequently as heavy showers. In the north, a cold summer, which is not infrequent in Tohoku and Hokkaido, can cause an epidemic of insect pest infestation and plant diseases.

TABLE 2

Consumption[a] of Chemical Fertilizers in Japanese Agriculture

Year	Nitrogen as N	Phosphate as P_2O_5	Potash as K_2O
1957	592 (100)	389 (100)	386 (100)
1962	699 (118)	493 (129)	508 (132)
1967	889 (150)	671 (173)	651 (168)

[a]Figures indicate amounts of nutrients in 1,000 tons (figures in parenthesis show rates of increase).

More than 1,200 diseases and 2,500 insect pests are known to exist for major economic crops in Japan (TABLE 3). In order to sustain high yields, farmers in Japan must rely heavily upon the use of pesticides.

Trends in Pesticide Use in Japan

The introduction of a wide variety of modern synthetic pesticides in Japan started soon after World War II, as in other countries. The agricultural production of Japan dwindled greatly during World War II due to the shortage of farm labor and farm materials. There was a big shortage of food when the war was over and increased food production was the most important and urgent national need. Food production had also been of high priority during the War, and pest control was encouraged by the Government in order to prevent loss and to secure the greatest possible food supply. A pest forecasting program was