CRR DISCUSSION PAPER SERIES　A

Discussion Paper No. A-37

Maintenance of Shared Resources and the Use of Agricultural Pesticides Considered in Terms of Health Risks and Agricultural Marketing

Etsusaku Shimada

February 2020

Center for Risk Research

Faculty of Economics

SHIGA UNIVERSITY

1-1-1 BANBA, HIKONE,

SHIGA 522-8522, JAPAN

Maintenance of Shared Resources and the Use of Agricultural Pesticides Considered in Terms of Health Risks and Agricultural Marketing

Etsusaku SHIMADA

1 Introduction

Under the Law for Strengthening the Agricultural Business Base, the rationalization of farm management and the certification of farmers and group farming are promoted. There are important infrastructure functions necessary for the improvement of agriculture, such as the liquidation of farmland, farm roads, and irrigation facilities. Farmers associated with these policies have access to financial support from the local administration to receive various rights for when they engage in production activities such as agricultural land use. On the contrary, the requirements of efficiency and productivity have caused soil contamination and water pollution instigated by increasing use of agricultural chemicals.

Farmers are forced to achieve short-term management goals in the competitive market. This reality can make it difficult to cooperate with other farmers to maintain sustainable agriculture and manage shared resources. In other words, farmers’ pursuit of production efficiency carries the risk that the rural environment, with its multifaceted functions, could suffer serious damage, even involving fisheries. Conserving biodiversity is regarded as internationally important. The use of agricultural chemicals is recognized as one of the primary factors threatening the biodiversity. Its impact is equal to the disappearance of habitat brought about by overdevelopment and overfishing (Millennium Ecosystem Assessment, 2005).

The first issue is dioxin contamination in water, which was highest in the 1960s and 1970s, according to Masunaga (2000). It was caused by pentachlorophenol (PCP) and chlornitrofen (CNP) herbicides. Furthermore, in recent sediments, contamination from herbicides used in the past contributed more than equivalent from industrial and household combustion. Most of the dioxins derived from herbicides still remain in the farmlands and continue to contribute to their outflow of fine particles containing dioxins into rivers, lakes, and the sea by various routes. Plankton absorbs the dioxin from fresh water and seawater, which is consumed by small fish, who are then eaten by bigger fish. The concentration of dioxin in fish is presumed to be approximately 3,000 times as high as the concentration of dioxin in fresh water or seawater. Dioxin is concentrated in food chain process and will eventually be accumulated in the human body at the top of the food chain. Humans who live on food from plants and animals grown in contaminated soil and water are facing serious health problems.

The next issue is neonicotinoid pesticides. These pesticides are the most widely used insecticides in the world, based on nicotine-like ingredients and have been in the market since the 1990s. This insecticide is convenient for agricultural producers because these can be sprayed less frequently. The apparent “reduced pesticide” requirement levied on certified farmers, such as eco-farmers, can be achieved easily. For example, neonicotinoid pesticides can be used in the seeding boxes that are used to raise rice seedlings. Thus, the load on the environment seems to be small. The Ministry of Agriculture, Forestry and Fisheries proactively recommends this practice.

When neonicotinoid-based pesticides came into the market, little was known about their long-term toxicity and effects on ecosystems, including humans. Originally, neonicotinoid pesticides were considered to have a greater neurotoxicity for insects than for vertebrates, and they were considered safe for humans. A wide range of neonicotinoid products have been developed to replace conventional agricultural chemicals and also for household pest control and pet treatments since the 2000s. These products have been used in large quantities without clearly proving its safety. However, the effects on humans are gradually becoming known. There are also reports on the effects of neonicotinoid pesticides on birds and mammals; these reports point out several of the dangers. There are accounts of increasing numbers of patients who complained of poor health at the same time they used the neonicotinoid pesticides. Moreover, there is the risk of known fetal developmental disorders. For these reasons, neonicotinoid pesticides have become a worldwide problem. According to Kuroda (2012), these pesticides have chemical structures similar to nicotine, which is an addictive chemical that affects the nervous system. Neonicotinoids have greater effects on mammalian nAChRs and brain function, especially on brain development, than previously reported in binding assay studies. These can adversely influence human health, especially in adolescent brains.

Previously, pesticides remained on the surface of agricultural products, so they could be removed by washing. However, recent pesticides are increasingly water-soluble, so they penetrate the seeds. Therefore, these pesticides' insecticidal effects last even after the crops have grown. These insecticides are promoted as effective because they can protect the entire crop from pests. However, because they are used on such a large scale on farmland and public land, they are becoming a problem. One of the problems is that as the use of neonicotinoid pesticides expanded, the mass deaths of bees began to be reported around the world. Bees are pollinators that play an important role in farming. In Europe the movement to regulate the use of neonicotinoid pesticides began in the early 2000s.

In mid-2013, the European Commission announced a two-year provisional regulation for the use of three neonicotinoid pesticides and fipronil (another chemical that has the same penetrating capability and similar properties to neonicotinoid pesticides). This decision was based on precautionary principles that are applied when scientific evidence is not sufficient but the problem has a suspected significant impact on the environment and life.

In 2017, Yutaka Kameda's group (2017) found that honey, bees, and pupas all over Japan are widely contaminated by neonicotinoid pesticides. According to the report, this pesticide was detected in all 73 samples collected in nine prefectures from the Tohoku to the Okinawa regions. Over 60% of the honey exceeded the provisional standards of Japan. Neonicotinoid pesticides are connected with the mortality and mass death of honeybees and the disappearance of swarms seen in many countries. According to Kameda, "with some pesticides, half of the bees were found to die within 48 hours, it was also detected at high concentrations in wild honey bees, which may have already been affected over a wide area." (Kameda, 2017).

At the same time, the American scientific journal *Science* published two research results [1] revealing that neonicotinoid pesticide is harmful to bees and bumblebees on June 29, 2017. One of the studies is the result of a large outdoor survey conducted in the United Kingdom, Germany, and Hungary (Woodcock et al., 2017). This study covered the first large-scale outdoor research conducted, and it was done by the Center for

---

[1] Woodcock, B. A., J.M. Bullock, R.F. Shore, M.S. Heard, M.G. Pereira, J. Redhead, and L. Ridding (2017) Country-specific effects of neonicotinoid pesticides on honey bees and wild bees, *Science* 356(6345): 1393-1395. 10.1126/science.aaa1190.

Tsvetkov N., O. Samson-Robert, K. Sood, H.S. Patel, D.A. Malena, P.H. Gajiwala, P. Maciukiewicz (2017) Chronic Exposure to neonicotinoids reduces honey bee health near corn crops, *Science* 356(6345): 1395-1397. 10.1126/science.aaa7470.

Ecology & Hydrology of the UK Government Research Institute. Along with the results of a 2015 research project that used 2,000 hectares of farms in the UK, Germany, and Hungary, they found that bees exposed to neonicotinoid pesticides had a 24% reduction in overwintering hibernation.

Another study (Tsvetkov et al., 2017) conducted by a research team at York University, Canada, found that larvae given pollen contaminated with a neonicotinoid pesticide had a 23% reduction in average life expectancy. As a result of observing a bee field far away from a beefare around a corn field, it was found that most of the neonicotinoid-contaminated pollen collected by the honey bees was not from corn. Furthermore, according to Tsvetkov et al. (2017), the contaminated pollen was found over a long period of time, from May to September. The residual pesticide concentration in wild plant pollen collected by the bees was measured. It was then confirmed that the larva's life span was shortened by feeding them pollen adjusted to the concentration of clothianidin. The researchers suggested that the contamination of this wild plant was from "neonicotinoids, which are water-soluble, flow out from the farm to the surrounding environment and are taken up in plants favorable for the bees," demonstrating that contamination to the water system can cause contamination diffusion."

Three characteristics of neonicotinoid pesticides that have an impact on bee-containing ecosystems are neurotoxicity, permeability, and persistence. The strong neurotoxicity kills many insects, including beneficial insects, in addition to the target pests. In other cases, the pesticide imposes obstacles that make it difficult for insects to survive. In addition, because of its solubility, there is a risk that it will enter the surrounding vegetation and groundwater and spread to areas where insecticides are not used. Although regulations regarding neonicotinoid pesticide use have advanced in many countries, the problems associated with it seem to have been ignored in Japan. At present, there are no restrictions on the use of neonicotinoids. In fact, there is a movement in the opposite direction to deregulate usage. It considered a useful technology to improve production efficiency and is an accepted inevitability of the agricultural system.

Two factors promote the use of neonicotinoid pesticides in Japan. First is the presence of colored grain standards for the quality grade of paddy rice or brown rice in the Agricultural Products Standard Regulations. The stink bug that creates the spotted rice problems has been designated as a specified pest by Control of Specified Pests (Article 22) in the Plant Protection Act. The death of honeybees in Japanese agriculture is the main damage caused by neonicotinoid pesticide poisoning when it sprayed for the purpose of controlling spotted stink bugs during the rice flowering period of rice in paddy rice cultivation. Spotted stink bugs suck during the period when the rice seeds are soft. The area where the juice was sucked out turns blackish and the rice becomes spotted. It is thought that neonicotinoid pesticides target the nerve cells in the brains of insects. Due to water-solubility, the neonicotinoids are then spread widely through streams and groundwater.

Spotted rice reduces the selling price of brown rice and creates systemic problems. The Agricultural Products Standard Regulations on Agricultural Product Inspection (Article 11) defines the quality grades of glutinous brown paddy rice. First class rice must contain less than 0.1% of colored grains; second class rice must be less than 0.3%; and third class rice must be less than 0.7%. Although the inspection under the law is optional, it is necessary to prove inspection by the Agricultural Products Inspection Law in order to indicate the place of origin, varieties, and year of production for rice sold in containers and packaged according to the Food Labeling Standards (Article 19) based on the Food Labeling Act (Paragraph 1, Article 4). Therefore, there is a de facto duty to inspect all rice to that is to be distributed in the market. Farmers may still sell rice a certificate of origin if the prefecture name is displayed based on the Traceability System for Rice/Rice Products. However, it is also obligatory to indicate “no production area inspection.” It is in the producers’ interest to control stink bugs by spreading neonicotinoids in paddy fields to prevent spotted rice since the selling price of brown rice varies depending on whether it is high grade or lower grade rice based on percentage of colored grains as defined in Article 11.

However, spotted rice is not a health hazard. It can easily be removed in the sorting process using a color sorter. The standard of colored grains related to the quality grade of brown paddy rice was considered important when high-performance color sorters did not exist or were not widely used. However, now that inexpensive high-performance color sorters are widely available and used for most of the rice distributed in Japan, the historical role of grading is no longer important. The standard only protects a very small number of rice millers who do not have a color sorter. This standard not only promotes unnecessary pesticide spraying to control spotted rice stink bugs, which produces a negative impact on the paddy field ecosystem, but it also imposes significant costs and additional labor for producers. Spotted rice stink bugs are currently specified as “Designated Pests” because as they “tend to cause serious damage to crops, special measures are required” as defined by the Plant Protection Act (Article 22). The Designated Pests specification should be canceled by revision of the Enforcement Regulations of the Plant Protection Act.

Neonicotinoid pesticides have the potential to have serious adverse effects not only on bees but also on ecosystems, and their negative effects on human health have been scientifically proven. The World Health Organization (WHO) has requested their reduction internationally due to its structure similar to nicotine and strong concerns about the impacts of neonicotinoid pesticides on human health, particularly on the development of the fetus and children. As interest in organic foods has increased and agricultural crop contamination due to environmental pollution is becoming apparent in Japan and all over the world, a quest for common ways to recognize and manage soil and water quality must be commenced. In recent years, an inherent problem in Japanese government agricultural policy is the fact that it gives priority to marketability and productivity. This has a tendency to deteriorate the food production environment. Sustainability in domestic agricultural production has taken second place under policies promoting certified farmers and village farming.

In Japanese agriculture, there is general information on how eco-farmers, certified farmers, and village farmers use of dioxin-emitting pesticides and neonicotinoid pesticides. Different forms of agricultural communities have demonstrated differences in pesticide use, including how eco-farmers, certified farmers, and community farmers use of dioxin-emitting and neonicotinoid pesticides. Furthermore, for the use of neonicotinoid pesticides, the results of an empirical analysis comparing the area of rice land cultivated depends on the production factors and the area of fruit tree lands cultivated rely on insect pollination services. This analysis highlights how rice farmers are eroding the interests of orchard farmers. These are pioneering studies and make valuable contributions in agricultural economics research.

2 Improvement of Production Efficiency of Farmers

2.1 Certified Farmers

The certified farmer system was established in 1993. It allows municipalities to approve five-year plans designed to improve agricultural management according to local circumstances. It is based on the Agricultural Business Foundation Strengthening Promotion Law. Certified farmers can receive management income stabilization measures. Production condition disadvantage correction subsidies and income reduction effect mitigation grants are available. Therefore, certified farmers can receive a supplement for below-cost pricing for the production of wheat and soybeans. They can also to obtain a safety net against a reduction of income for rice, wheat, and soybeans. This system also targets group farming.

Furthermore, there is taxation support, called the Agricultural Management Foundation Strengthening Reserve Fund. In the case of a certified farmer who file a blue form[2] for an income tax return and lays aside subsidies for measures that stabilize management income, this reserved fund can then be included in the account of necessary expenses for the individual or in deductible expenses for a corporation.

Next, a certified farmer can receive support to strengthen the agricultural management base. This is a reduction of interest on the initial five years of a loan, such as a long-term, low-interest loan for management improvement, i.e., the funding required for the acquisition of agricultural land, facilities, or machinery or for long-term

[2] The Blue Form is equipped for the exclusive use by those who are qualified to receive preferential treatments. The Blue return can be used by tax payers who gain taxable income from Real estate, business or Forestry. It is necessary to obtain approval from the head of the tax office by an application in advance. By that, you are granted various privileges in calculation of your income tax.

working capital, and Super L fund[3]. Also, certified farmers can receive national treasury subsidies for outstanding loans to introduce agricultural machinery. Also, there are subsidies that pay half of the insurance premium on the farmers' pension—from 4,000 JPY to 10,000 JPY—for certified farmers who make a blue declaration. In addition, certified farmers can benefit from investment by Agribusiness Investment Development Co., Ltd. (Agri) and Investment Limited Partnership (LPS) based on the Agricultural Corporation Investment Facilitation Act.

These policies are focused on strengthening the management structure by minimizing costs and pursuing production efficiency of farmers. However, there is concern that such a policy, which is biased toward pursuing production efficiency and strengthening the management structure, may generate negative by-products such as environmental pollution. This is because there is a possibility that a social disadvantage can occur as one aspect of private profit. It is important to note that the natural environment is used by all living beings.

2.3 Village Farming

For farmers, the rural environment is a shared resource. It is an important external economy that provides a stable supply of clean water and rich and soil. Therefore, in order to continuously gain the benefits from this resource, it is necessary for members of local communities to cooperate in activities such as village farming. Thereby, it is expected that the goal will be to reduce uneconomical external conditions and to promote and achieve healthy external economies. Village farming is generally

[3] Super L fund is a comprehensive fund that supports the management improvement by the independence and ingenuity of farmers who have been certified under the Agricultural Management Improvement Plan, which is handled by the Agriculture, Forestry and Fisheries business of Japan Finance Corporation.

conceived as “a basic unit of social life in a spontaneous community.” Various groups and social relations share territorial bonding, and form a community. The concept of local communities formed around agriculture in district municipalities is also called agricultural settlement (Ministry of Agriculture, Forestry and Fisheries).

In the direction of new food, agriculture, and rural policy (new policy)[4] announced by the Ministry of Agriculture, Forestry and Fisheries in 1992, “promotion of corporatization” to strengthen organizational management structure and “upbringing of the management body” were important issues. According to Article 28 of the Food, Agriculture, and Rural Areas law enacted in 1999, village farming is a farmers’ organization that takes necessary measures to promote agricultural production activities and is entrusted to collaborate with other agrarian community-based organizations. It is restricted to persons exclusively engaged in agriculture and does include women and senior citizens (Yabiki, 2015).

Meanwhile, to accelerate the development of specific agricultural corporations and organizations, item cross-sectoral management stabilization measures (subsequently renamed “paddy fields/upland farm management income stabilization measures”) started in 2007. They emphasized management features such as “income” and “full-time employees” and the viewpoint of maintaining and revitalizing rural societies while managing local resources that include farmland. However, issues related to managing regional resources such as farmland and revitalizing rural society were neglected. Village farming has increased throughout the country due to this measure. The solution of regional problems, which local residents have discussed, are the need for a “place for

[4] 1. Development of land use type agriculture, 2. Development of management and efficient use of farmland, 3. Rice production adjustment and management, 4. Pricing policy, 5. Agriculture that contributes to environmental conservation, 6. Ensuring proper use of farmland and securing rural settlement conditions, 7. Initiatives for mountainous areas.

discussion, reasons for agreement, an organization coordinator for system implementation, funds available for activity, and through these the residents can solve, by unique collaborative community activities, changes in life style and a new way of thinking." Linking business with satisfaction and fulfillment of life could revitalize the agricultural community and maintain the Commons as a driving force.

Although the government measures focus on the production function of village farming, village farming was originally organized to play a role in settlement, including preservation of regional resources in the process of its establishment (Yabiki, 2015). Therefore, village farming should contribute to the maintenance of shared resources and the preservation of the environment, which is essentially part of its original nature and role. According to Hayami (1986), family small farms are efficient production organizations with the resources and technology provided. However, their efficiency cannot be achieved independently. For example, if one farmer fails to control pests in his or her field, it will spread to the fields of neighbors. As is true in this case, some farmers could benefit from using neonicotinoid pesticides, but some farmers could be harmed by it. However, if they work together as members of the same community to maximize community interests, there will be a restraint on the use of pesticides. However, this does not apply if the pollution is widespread beyond the community area due to the water-soluble nature of the neonicotinoid pesticides. We want to examine the effect of village farming on the use of pesticides, along with the use of dioxin-generating pesticides.

2.3 Eco-farmers

“Eco-farmer” is the nickname for farmers who are certified by the prefectural governor because of their “plans submitted concerning the promotion of the introduction of highly sustainable agricultural production methods.” These plans should include soil-building technology, techniques for keeping the soil in good condition, and chemical fertilizer and chemical pesticide reduction technology based on Article 4 of the Law Concerning the Promotion of the Introduction of a Highly Sustainable Agricultural Production System enacted in July 1999. The term “eco-farmer” was selected from applications submitted to the National Conservation Agriculture Promotion Council in August 2000 (Ministry of Agriculture, Forestry and Fisheries, Shiga Prefecture). On becoming an eco-farmer, direct-payment grant assistance is possible for environmental conservation agriculture and special resources are available from the agricultural improvement fund (Ministry of Agriculture, Forestry and Fisheries).

Since the establishment of the eco-farmer system in 1999, the number of accredited eco-farmers continued to increase with the rise of environmental awareness. From only 12 eco-farmers nationwide in 2000, there were 50,000 by 2005, 100,000 in 2007, and 200,000 in 2010. This increase was expected to promote highly sustainable agricultural methods nationwide. In some prefectures, however, the number of certified eco-farmers is sluggish, such as in Tokushima, Ehime, Mie, Iwate, and Aomori prefectures. The manner in which eco-farmers are accepted in contemporary Japanese agriculture differs by region and prefecture. In Tokushima prefecture, for example, in an interview with the Tokushima newspapers (August 4, 2015), a farmer said, “reducing pesticides and chemical fertilizers, increases the work load such as grass cutting, and it is also necessary to check whether insect pests are increasing frequency,” and “income does not increase with the extra labor.” “Eco-Farmer’s agricultural products are not valued in the market and the middleman wholesaler will not buy it at an acceptable price," said a farmer. It is conceivable that there is a problem in the efficiency of production and the effectiveness of sales promotion activities for eco-business entities. It may be necessary to consider countermeasures including a distribution department that deals with handling of crops that do not conform to the sales standards in shipping and collection.

3 Econometric Analysis

3.1 Model and Results (Accumulation of Dioxin)

In this paper, we analyzed how changes in the numbers of certified farmers, village farmers (individuals and corporations), and eco-farmers influenced pollutant (dioxin) deposition on shared resources such as water and soil. The dataset is composed of 45 prefectures observed 2001 through 2013, with the exception of Hokkaido and Okinawa prefectures. The data sources are in the Ministry of the Environment (2014)[5]

Dioxin deposition is the dependent variable, and it is found in four locations: (a) dioxin sedimentation in a water area (variable symbol: Bot_war), (b) sedimentation in groundwater (Gr_war), (c) sedimentation in the general environment (Gen_Env), and (d) sedimentation by regional summary survey (Soil). With respect to each location, we estimate the number of certified farmers (Certified_far), individual village farming (V_Inv), corporate village farming(V_f_Inv), and eco-farmers (Eco_far) using multiple regression analysis by robustness test.

[5] See Note 1.

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max	Unit
Bot_warter	585	39.68	22.43	6	112	pg-TEQ/L
Gr_warter	585	18.22	14.27	0	88	pg-TEQ/L
Gen_envir	585	27.03	26.61	0	228	pg-TEQ/g
Soil	585	39.09	41.11	0	365	pg-TEQ/g
Eco_farmer	450	3588.31	4168.64	0	25568	unit
Certified_farmer	585	4153.66	2955.62	441	13785	unit
V_farm_Indiv	405	242.37	216.74	0	822	unit
V_farm_Corp	405	38.82	52.45	0	298	unit

The average value of the pollutant concentration and the survey sites in 2001 are calculated as follows.

Water quality of public water bodies: Regarding the water quality of public water bodies, a survey was conducted at 2,213 points nationwide (1,674 rivers, 95 lakes, 444 sea areas, and 2,635 samples), and the average value for each prefecture was calculated.

Groundwater quality: The groundwater quality was surveyed using 1,473 specimens nationwide at 1,480 points, and the average for each prefecture was calculated.

Soil: Regarding soil, a general environmental survey and a survey of the surroundings of the source were conducted at 3,735 locations nationwide, with the same number of samples, and the average value for each prefecture was calculated.

Display method for target substances measurements and measurement results: Dioxins (isomers shown for reference among PCDD, PCDF, and coplanar PCB) were measured, and the measurement results were shown as toxic equivalents (TEQ).

This is the sum of the measured concentrations of each isomer multiplied by the Toxicity Equivalence Factor (TEF).

Table 2. Quantitative results with robustness (Accumulation of Dioxin)

	(a)			(b)			(c)			(d)		
			t-values			t-values			t-values			t-values
Dependent Var	Bot_warter			Gr_warter			Gen_envir			Soil		
Eco_farmer	-0.0015	***	-5.38	-0.0005	***	-2.60	-0.0019	***	-6.27	-0.00301	***	-6.65
Certified_farmer	-0.0001		-0.22	0.0006	**	2.15	0.0012	***	2.59	0.0018	***	2.80
V_farm_Indiv	-0.0105	**	-2.25	-0.0044		-1.29	-0.01023	*	-1.92	-0.0073		-0.91
V_farm_Corp	-0.0059		-0.29	-0.0029		-0.25	-0.1836		-0.58	-0.0247		-1.02
Constant var	40.4851	***	16.27	18.7177	***	12.66	29.4587	***	11.58	37.76856	***	9.79
Number of obs	359			359			359			359		
R2	0.0646			0.0332			0.0928			0.0954		

(1) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

3.2 Model and Results (Spread of Neonicotinoids Pesticides)

Secondly, we analyzed how changes in the number of certified farmers, the number of village farmers (individuals and corporations), and the number of eco-farmers have influenced the shipment volume that reflects the demand for and spread of pollutants.

The dataset is composed of 45 prefectures from 2006 through 2010 except Hokkaido and Okinawa prefectures. The data sources are written in the Center for Environmental Risk Research, National Institute for Environmental Studies [6].

6 Shipment of Neonicotinoids pesticides: Database of Agricultural Chemicals, WebKis-Plus, Center for Environmental Risk Research, National Institute for Environmental Studies (See Note 2)

Table 3. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max	Unit
Acetamiprid	225	1.27	1.96	0.02	22.6	t
Imidacloprid	225	1.41	1.02	0.07	4.57	t
Clothianidin	225	1.05	1.03	0.01	8.21	t
Tiapride	225	0.47	0.76	0	4.12	t
Thiamethoxam	225	0.62	0.69	0	4.52	t
Dinotefuran	225	3.11	3.09	0.01	16.08	t
Nitenpyram	225	0.18	0.24	-0.02	1.33	t
Fipronil	225	0.89	0.70	0	4.98	t
Eco-farmer	225	3824.16	3976.29	1.00	21889	unit
Eco-farmer % to farmer	180	0.06	0.07	0.00	0.58	ratio
Certified farmer	225	4612.15	3143.61	789	13785	unit
Certified farmer % to farmer	180	0.07	0.04	0.01	0.17	ratio
Individual Village Farmer	225	238.56	213.12	0	811	unit
Individual Village farming % to farmer	180	0.00	0.00	0.00	0.02	ratio
Cooporate Village Farmer	225	32.74	42.76	0	238	unit
Corporate Village farming % to farmer	180	0.00	0.00	0.00	0.01	ratio

We chose Dinotefuran, which is the largest volume for the trade of neonicotinoid pesticide, for our analyses and used prefectures' dummy for the analysis at Table 4.

Table 4. Quantitative results with robustness

Variables	Neonicotinoid (Dinotefuran)		t-value
			t-value
Eco farmer	-0.0001	***	-2.91
Certifield farmer	0.0004	*	1.71
Individual village farming	0.0049	***	3.48
Corporate Village farming	0.0066	**	1.42
Aomori	2.5064	***	7.06
Iwate	8.8053	***	8.39
Miyagi	6.4280	***	5.04
Akita	5.9529	***	6.67
Yamagata	4.4806	***	9.15
Fukushima	3.3545	***	3.23
Ibaraki	2.5120	***	5.93
Tochigi	1.1290	**	2.08
Gunma	1.1992		1.18
Saitama	1.8247	*	1.71
Chiba	3.3112	***	4.93
Tokyo	2.1077		1.13
Kanagawa	1.7784		1.08
Niigata	11.3036	***	9.28
Toyama	2.3532		0.96
Ishikawa	3.7961	**	2.03
Fukui	2.3900		1.05
Yamanashi	3.5101	**	2.01
Nagano	3.6145	***	5.24
Gifu	2.2628		1.24
Shizuoka	2.9204	***	3.41
Aichi	2.7773	**	2.49
Mie	2.157082		1.24
Shiga	2.1611		0.97
Kyoto	2.5201		1.28
Osaka	2.6054		1.38
Hyogo	0.1978		0.10
Nara	2.8691		1.49
Wakayama	4.2324	***	3.23
Tottori	2.1474		1.07
Shimane	1.1477		0.54
Okayama	2.5160	*	1.73
Hiroshima	0.8141		0.36
Yamaguchi	2.3120		1.18
Tokushima	2.3285		1.50
Kagawa	2.4654		1.32
Ehime	5.2718	***	4.87
Kochi	2.2656	*	1.75
Fukuoka	2.2254		1.41
Saga	0.0242		0.02
Nagasaki	1.4404	*	1.78
Kumamoto	1.0048		1.35
Ooita	-0.5829		-0.43
Miyazaki	1.0763	***	3.15
Number of obs	225		
R^2	0.9483		

* Degree of significance expressed as
*** $p < 0.01$ ($t > 2.57$). ** $p < 0.05$ ($t > 1.96$). * $p < 0.10$ ($t > 1.64$) .

Table 5. Estimated results by Panel Data analysis to explain the expected use of Neonicotinoid pesticide

Variables	(a) Fixed-Effect Neonicotinoid (Dinotefuran)	z-value	(b) Random Effect Neonicotinoid (Dinotefuran)	z-value	(c) Dynamic Panel-Data 1 Neonicotinoid (Dinotefuran)	z-value	(d) Dynamic Panel-Data 2 Neonicotinoid (Dinotefuran)	z-value
Lag operator of Dependent var.	—	—	—	—	-0.4511	-1.01	-0.5707 *	-1.85
General environment	-0.1422 *	-1.70	-0.0155 *	-1.85	-0.1543	-1.04	-0.0215	-1.25
Paddy ratio to the field	45.0297 ・	1.56	4.0609 **	2.02	55.3170 ・	1.44	57.1220 ・	1.54
Fruit farm ratio to the field	-48.9418 **	-2.26	-3.7718	-0.88	-60.9116 **	-2.03	-44.5086	-1.39
Eco farmer	—	—	—	—	—	—	-0.0001	-0.97
Eco farmer % to farmer	-2.6712 *	-1.92	-2.6225 *	-1.85	-0.7132	-0.35	—	—
Certifield farmer	—	—	—	—	—	—	-0.0002	-0.27
Certifield farmer % to farmer	4.0594	1.08	8.1490 **	2.21	4.1525	0.93	—	—
Individual village farming	—	—	—	—	—	—	0.0114 **	2.14
Individual village farming	66.2358 ・	1.60	42.4942	1.04	-29.5322	-0.99	—	—
Corporate village farming	—	—	—	—	—	—	-0.0009	-0.08
Corporate village farming % to farmer	-249.3859 *	-1.74	-164.7478	-1.17	-189.3481	-1.00	—	—
Hausman test	Fixed effect (Prob > Chi2 = 0.0003)							
Number of obs	180		180		90		90	

* Degree of significance expressed as
*** p < 0.01 (z > 2.57). ** p < 0.05 (z > 1.96). * p < 0.10 (z > 1.64) . ・ p < 0.15 (z > 1.43).

4 Results of the Quantitative Analysis

4.1 Certified Farmers

The results of the econometric analysis significantly demonstrate that as the number of certified farmers increases, dioxin deposits in the groundwater and soil also increase (see Table 2). Certified farmers work hard to strengthen the management structure required by the system. This provides the incentive for certified farmers to abandon sustainable agricultural methods as soil-building and cultivation of agricultural crops that do not rely on chemical fertilizers, pesticides, and herbicides since these are not directly quantified as evaluation criteria.

The quantity of the number of certified farmers was also significantly related to the amount of approximately all contaminants in the system, including the quantity neonicotinoid pesticides shipped. Similar to the accumulation of dioxin, it is conceivable that certified farmers seek production efficiency and profitability without any regard for the effects on the ecosystem. These priorities tend to promote the use of neonicotinoid pesticide as a substitute for regulated pesticides.

4.2 Corporation Village Farming

An increase in corporate village farming did not indicate a decrease in dioxin, which confirmed the author's hypothesis. Also, no significant results were obtained regarding the use of neonicotinoid pesticides. It is inferred that corporate village farming has does not play its original role, as Hayami (1986) explains. Neonicotinoid pesticides are water-soluble, and contaminants can spread beyond the user's agricultural community through groundwater veins. Therefore, if the affected farmland is outside the source community, it will not be possible to build cooperation.

Village farming involves rural agricultural communities, a social capital that protects shared resources indispensable in rural areas. However, it is possible that this protective role can no longer be fulfilled. In J (new policy) of new food, agriculture, and rural policy announced by the Ministry of Agriculture, Forestry and Fisheries in 1992, in the Food, Agriculture and Rural Areas law constituted in 1999, and in the paddy fields/upland farm management, income stabilization measures started in 2007 have changed the emphasis. As a result, the objective of “Maintaining and revitalizing rural society while managing regional resources including agricultural land” originally possessed by village farming communities tends to be neglected (Takeyama and Yamamoto, 2013). Village farming has been impacted by such measures. The nature of the original agricultural community has been impaired and its purpose cannot be completely fulfilled. The government measures are similar to the characteristics seen in the certified farmer system, which focuses on the production function of village farming. However, the original role of village farming was to preserve regional resources that included farmland, and this was rooted in the farmers' trust relationships, and this is unlikely to be fulfilled.

4.3 Individual Village Farming

The results show that as the number of individual village farmers increases, deposition of dioxin in the bottom of the water areas (rivers/lakes and wetlands/sea areas) and in the general environment index decreases. Individual village farming does not operate in the same way as corporate village farming. The farmers are economically independent units, and it is natural for them to perform production activities that focus on efficiency in contemporary competitive markets. Nevertheless, it is important to note an increase in personal village farming that is significantly related to a decrease in dioxin.

According to the original role of village farming, village farming was predicted to function and contribute to preserve agricultural lands and water sources and prevent pollution. Therefore, if the government can take measures to support village farming based on cooperative relationships among farmers original agricultural communities will develop in rural areas across the country. It is expected that the village farmers will enhance their inherent functions and that the external problems such as water quality and soil contamination can be suppressed and the external economy necessary for agriculture will be promoted.

However, for neonicotinoid pesticides, we did not obtain the expected significant results. This suggests that the common understanding that neonicotinoid pesticides are toxic to insects that maintain ecosystems could be incorrect or that farmers are careful in their use of neonicotinoid pesticides.

4.4 Eco-farmers

The econometric analysis strongly indicated that the increase in the number of eco-farmers makes it possible to reduce the deposition of dioxin at the bottom of rivers, lakes, wetlands, and groundwater. This is shown in the general environment survey indexes and regional survey indexes. These results point to the outcome of “introducing highly sustainable agricultural production methods” approved by eco-farmers. Eco-farming integrates soil-building efforts and chemical fertilizer and pesticide reduction technology.

Similarly, it was estimated that neonicotinoid pesticide consumption could decrease as the ratio of eco-farmers to farmers increases. However, we should still note that there is a lack of regulation in certifying eco-farmers who are not now obliged to produce “Special Cultivation Agricultural Products.” These products must be grown with reduced use of chemical pesticides to less than 50% of prefectural standards, including neonicotinoid pesticides. Therefore, they are not prohibited from using neonicotinoid pesticide as a substitute for regulated pesticides.

4.5 Considerations and Discussions

From the results in Table 5, the reasons for the use of neonicotinoid pesticides (Dinotefuran) can be explained in terms of the following variables: dioxin pollution concentration, area ratio of fruit farm to farmland, and area ratio of paddy to farmland in addition to eco-farmers, certified farmers, individual village farming, and corporate village farming. Panel data composed of these variables for 45 prefectures in Japan is used for fixed effect analysis. It is conceivable that neonicotinoid pesticide is being used as an alternative while the use of pesticides that release dioxin has been restricted. Furthermore, the eco-farmer scheme seems to have had some effect in lowering the use of neonicotinoid pesticides due to the rise of consciousness regarding the environmental preservation of agriculture. However, because statistical results for some areas are insufficient, countermeasures against the use of pesticides are still required. On the other hand, the use of neonicotinoid pesticide tends to be comparatively restrained in areas of fruit tree cultivation. However, in some areas, artificial pollination is carried out without relying on insects. In these cases, there may be no link to the motivation to suppress the use of the pesticides. In addition, although the number of farmers per amount of arable land is high, it is possible to carry out more careful cultivation. Therefore, it is considered easier to respond to harmful pests, and the existence of a sufficient labor force makes it difficult to substitute with pesticides.

5 Conclusion

In this paper, we assume that the causes of the accumulation of dioxin sediment in Japanese waters (rivers, lakes, wetlands, and seas), groundwater, and soil and the spread of neonicotinoid pesticides in rural areas of Japan are associated with the numbers of certified farmers, individual village farmers, corporate village farmers, and eco-farmers. A quantitative analysis with annual statistics from 45 prefectures, excluding Hokkaido and Okinawa, from 2000 to 2013 for dioxins and from 2006 to 2010 for neonicotinoids was carried out.

As the number of certified farmers increased, the accumulation of dioxin increased in the groundwater and in a wide range of soils. There was no statistically significant increase in dioxin in the environment due to changes in the number of cooperative type farming villages in either water bodies or in the soil. However, as the number of individual village farmers increased, the deposition of dioxin on the bottom of waters (rivers/lakes/sea areas) and in the soil (from the survey on the general environment) was significantly reduced. Furthermore, we also obtained significant results showing that an increase in the number of eco-farmers led to a significant reduction in accumulation of dioxin on the bottom of water courses (rivers/lakes and wetlands/sea areas), in underground water, as well as in the general environment survey indexes and regional survey indexes.

Our analysis of the characteristics of farmers and agricultural communities also allowed us to estimate the causes of the spread of neonicotinoid agricultural chemicals. When the ratio of paddies to fields increases, the use of neonicotinoids also increases, which shows a positive influence. However, when the ratio of fruit farms to fields increases, the use of neonicotinoids decreases, indicating a negative influence. Paddy rice farming currently depends on the use of neonicotinoids as a pesticide against stink bugs, which damage rice crops. Most vegetable farmers also use insecticides, including neonicotinoids, but fruit farms need insects for pollination and so do not use neonicotinoids. Also, fruit farmers and vegetable farmers must corporate with each other, and in some cases one farmer manages both vegetable fields and orchards. Moreover, when the ratio of eco-farmers to farmers increased, the use of neonicotinoid pesticides seems decreased. Furthermore, neither individuals nor corporations have done enough to reduce the use of neonicotinoid pesticides.

The papers of Woodcock et al. (2017) and Tsvetkov et al. (2017) published in *Science*, June 30, 2017, revealed that neonicotinoid pesticides are strongly toxic for insects and that the use of neonicotinoid pesticides, which are water-soluble, destroys a wide range of ecosystems and threatens the sustainability of agriculture. These results were published in 2017. Therefore, it is conceivable that farmers and administrators in Japan are still not addressing this as a problem that needs an immediate solution. There is no effective prohibition or restriction policy on the use of neonicotinoid pesticides, and this means that the situation will be exacerbated.

The government must act in order to prevent farmers from improving productivity by pursuing profits through the use of pesticides and excessively strengthening management structure at the expense of important shared resources in rural areas. The government is required to reassess what village farming has been and ought to be. The current Japanese agricultural (JA) regime as seen in the Agricultural Products Standard Regulations on Agricultural Product Inspection is outdated and the rice distribution system and pricing based on quality rankings needs to be reassessed and revised to reflect market demand and global precautionary standards. The government should promote the cooperative relationships among farmers and to restrict the use of chemical fertilizers and agricultural chemicals to certain farmers and to ban the use of neonicotinoids altogether.

Satochi satoyama[7] is a shared resource not only for rice farmers but also for non-rice farmers and urban residents, who are the largest consumers of the crop. However, regarding the benefits of the Commons, such as insect pollination services, there may be conflicts of interest between rice farmers, non-rice farmers, and crop consumers. The distribution system under the current laws and regulations creates asymmetry of information that is advantageous for rice farmers and hinders the functioning of price competition mechanisms in healthy markets. For instance, the introduction of rational technologies in distribution has been neglected. To preserve shared resources and enable sustainable agricultural production, it is necessary to prohibit the use of neonicotinoid pesticides. It is also important to raise the awareness of urban residents who are beneficiaries of the Commons, and to provide them with accurate information. When the crops that have been nurtured by diverse biota are grown in Satochi satoyama's clean and abundant soil and water environment and the inhabited ecosystems that have coexisted with humans are traded properly in markets without information asymmetry, the quality of each product can be reasonably evaluated under the diverse needs of the consumers. Eventually, it is expected that farmers will be given incentives to preserve the Commons and grow crops that do not harm to the human body and the ecosystem. For these reasons, it is important to develop an appropriate market.

Globally, neonicotinoid pesticides are being restricted and, in some cases, are completely banned, including in EU countries, South Korea, and Taiwan. From the

---

7 Satochi satoyama comprises human settlements and several types of ecosystems, developed and managed through prolonged interation between humans and ecosystems. Satochi satoyama occupies more than 40 percent of Japan's total land. According to Ministry of the Environment (2020), Satochi satoyama is a space created by people working on nature. People have obtained energy such as firewood, materials such as building materials, and food from Satochi satoyama, and at the same time, have protected a place where various creatures such as Japanese killifish, frogs, and cats can live.

results obtained in this study, eco-farmers are able to produce goods with environmentally friendly farming methods, while certified farmers are using neonicotinoids in pursuit of larger profits. This suggests that the eco-farming methods can be generalized to all farmers in competition in the market as well as to certified farmers. It is not desirable for a specific farmer, i.e., a rice farmer, to increase profits at the expense of others, i.e., fruit farmers and vegetable farmers. As long as it seems difficult to trade with each other over the pesticides between rice farmers who are dependent on insecticide and farmers who are dependent on pollinators and there is a huge loss in the ecosystem and agricultural production, neonicotinoid pesticides must be completely banned.

In the future, it will be important to analyze the impact of environmental pollution from neonicotinoid pesticides on human health in terms of conditions such as carcinogenicity, immunotoxicity, genetic disorders, reproductive function, and fetal development. The resulting impacts on economic welfare due to this must be calculated. In order to suppress such damage from agricultural production methods, both the cost incurred by prohibiting or reducing the use of chemical substances such as neonicotinoid pesticides and the cost of removing residual agricultural chemicals accumulated in the production environment such as soil should be analyzed. Then, we need to compare this with the possible health hazards when those measures are not taken. The benefits that can be gained in the welfare economy by removing neonicotinoids must also be assessed.

Acknowledgments

In carrying out this research, I would like to thank Professor Tomoko Kinugasa (Kobe University) for her useful guidance and comments. I also received valuable discussion and advice from Emeritous Professor Mitoshi Yamaguchi (Kobe University), Professor Taiji Hagiwara (Kobe University), Professor Kenji Takeuchi (Kobe University). I express my deep appreciation to them all.

Appendix

Note 1

1. Data on certified farming is from “Certification status of agricultural management improvement plan by prefecture,” Ministry of Agriculture, Forestry and Fisheries (1999–2013).

2. Data on village farmers (individuals and corporations) is from “Number of farmers by organization type” by Ministry of Agriculture, Forestry and Fisheries (1999–2013).

3. By-prefecture data on farm rent of paddy fields and fields come from “Survey on Agricultural Land Price and Farm Rent” edited by Japan Real Estate Institute (1999–2013).

Note 2

1. Dioxin Sedimentation: Bottom of water area (rivers/lakes and wetlands/ sea areas), groundwater, general environment survey indexes, Regional summary survey indexes is quoted from “Environmental survey result on dioxins” edited by Ministry of the Environment (2001–2014).
2. Shipment of neonicotinoid pesticides: Database of Agricultural Chemicals, WebKis-Plus, Center for Environmental Risk Research, National Institute for Environmental Studies.
3. Number of certified farmers quoted from “Certification status of agricultural management improvement plan by prefecture” edited by Ministry of Agriculture, Forestry and Fisheries (2001–2014).
4. Village farmers (individuals and corporations) is quoted from “Number of farmers by organization type” edited by Ministry of Agriculture, Forestry and Fisheries (2001–2014).
5. Number of eco-farmers is quoted from “Certification status of highly sustainable agricultural production method introduction plan” by Ministry of Agriculture, Forestry and Fisheries (2001–2014).

References

Woodcock, B. A., J.M. Bullock, R.F. Shore, M.S. Heard, M.G. Pereira, J. Redhead, and L. Ridding (2017) Country-specific effects of neonicotinoid pesticides on honey bees and wild bees, *Science* 356(6345): 1393-1395. 10.1126/science.aaa1190.

Kimura-Kuroda , J., Y. Komuta, and H. Kawano (2012) The effects of neonicotinoid pesticide on humans and mammals**,** *Japanese Journal of Clinical Oncology* 21(1):46-56.

Hayami, Y. (1986) *Agricultural Economy*, Tokyo: Iwanami Shoten.

Honma, M. (1994) *Political Economy of Agricultural Issues*, Tokyo: Nikkei Inc.

Kameda,Y. (2017) NIKKEI, Aug 28, 2017

Masunaga S., (2000) The Origin of and Change in, Dioxin Pollution in Japan -The Contribution of Dioxins in Herbicides -, *Waste Management Research*, 11(3): 173-181

Matumura, M., N. Nishimura, and Y. Saijoh (1988) Plant Succession in Paddy Fields Lying Fallow in Hida Mountainous Regions Gifu Prefecture, *Japanese Journal of Ecology* 38(2): 121-133.

Millenium Ecosystem Assessment 2005

Ministry of the Environment (2020, Feb 22) What is Satochi satoyama, Retrieved from http://www.env.go.jp/nature/satoyama/satonavi/satochi/

Tsvetkov N., O. Samson-Robert, K. Sood, H.S. Patel, D.A. Malena, P.H. Gajiwala, P. Maciukiewicz (2017) Chronic Exposure to neonicotinoids reduces honey bee health near corn crops, *Science* 356(6345): 1395-1397. 10.1126/science.aaa7470.

Takeyama, K. and Y. Yamamoto (2003) *A Study on Evaluation System of Management Development and Regional Contribution in Village Farming Organization*, Bulletin of the Shimane Agricultural Technology Center, 41, pp.1-18

Tsvetkov N., O. Samson-Robert, K. Sood, H.S. Patel, D.A. Malena, P.H. Gajiwala, P. Maciukiewicz (2017) Chronic Exposure to neonicotinoids reduces honey bee health near corn crops, *Science* 356(6345): 1395-1397. 10.1126/science.aaa7470.

Tokushima Newspaper (2015). August 4, 2015

Yabiki (2015) Relationship analysis between cultivation abandoned land and village farming by statistical data, Technical Report of The National Institute for Rural Engineering, 217, pp.75-83