Pesticide-related Dermatitis in Saku District, Japan, 1975–2000

NOBUYUKI HORIUCHI, MD, SHINJI OGUCHI, MD, HIROSHI NAGAMI, PHD, YOSHIO NISHIGAKI, MD

Cases of dermatitis caused by pesticide exposures (n = 394), tabulated by the Division of Dermatology, Saku Central Hospital, Japan, from 1975 to 2000 are described. Dermatitis cases gradually decreased from 1975 to 2000, presumably accelerated by the phase-out of dermatitis-causing pesticides, including difolatan fungicide and salithion, an organophosphorous insecticide. Cases of chronic and solar dermatitides gradually decreased, which may be explained by reductions in the use of allergenic or photosensitive sulfur agents and organophosphates. However, the ratios of chemical burns from irritant pesticides—calcium polysulfide, dazomet, methyl bromide, chlorpicrin, paraqat/diquat, organophosphorus, quintozene, and glyphosate—rose in those years. Chemical burns from calcium polysulfide were responsible for most of the severe cases. *Key words*: pesticide dermatitis; chemical burns; calcium polysulfide; dazomet; methyl bromide; chlorpicrin; organophosphorus; paraquat.

INT J OCCUP ENVIRON HEALTH 2008;14:25–34

In Japan, the use of pesticides has accelerated since World War II, reducing manual labor and upgrading productivity in agriculture. However, it has also caused poisoning and other pesticide-related disorders, which in itself has been a grave issue for scientists of rural medicine.

Not so immediately vital is a matter that is apt to be overlooked. Pesticide-induced dermatitis affects many farmers, hampering their everyday lives and work. This effect of pesticides should not be ignored, particularly considering the physical damage it causes.[1–26] To identify pesticides that cause chemical burns with severe irritation, or allergic contact dermatitis, with the aim of supporting restrictions or prohibitions of their use, we report the trends in cases of pesticide-induced dermatitis we have diagnosed and treated, as well as the clinical characteristics of the cases.

Received from the Department of Dermatology, Saku Central Hospital, Usuda, Saku, Nagano, Japan. Supported by the Japanese Association of Rural Medicine.

Address correspondence and reprint requests to: Hiroshi Nagami, PhD, Division of Health Care, Saku Central Hospital , 197, Usuda, Saku, Nagano, 384-0301, Japan; telephone +81-267-82-2677; fax +81-267-82-7034; e-mail: <nagami@dia.janis.or.jp>.

METHODS

The 1,000-bed Saku Central Hospital, the Saku district's key medical institution, serves as a polyclinic, delivering primary to tertiary medical care to locals. Situated in the mountains of Central Japan (longitude 36°11', latitude 138°29'), 700 meters above the sea, the Saku district is known primarily for the production of rice, vegetables, and fruits.

Taking charge of the diagnosis and treatment of dermal disorders at the hospital's Department of Dermatology, the authors collected and analyzed data on clinical cases of pesticide-induced dermatitis over a period of 26 years, from 1975 to 2000. In taking their histories, patients seen in the department were questioned scrupulously about circumstances preceding the onset of any dermal disorder as well as between the onset and the initial visit to our hospital. Based on the history and clinical findings, cases of pesticide-induced dermatitis were identified for inclusion in the study

We analyzed the data relative to annual trends, gender distribution, age distribution, month of onset, causative pesticide, circumstances of onset, history of dermatitis, region of onset, outcome, complications, and clinical manifestations.

We classified the clinical manifestations into five categories, depending on the symptoms of the dermal disorders:

1. Chemical burn—inflammation that occurs as a highly toxic pesticide adheres to the skin and as the epidermis and/or skin is directly eroded or destroyed.
2. Acute dermatitis—contact dermatitis with primary irritation by pesticides or allergy-related contact dermatitis.
3. Solar dermatitis—dermatitis with phototoxic and/or photoallergic factors related to pesticide exposure.
4. Chronic dermatitis—dermatitis that appears in an acute form in the spring, when farm work begins, with repeated healing and exacerbation until autumn.
5. Other types—for example, purpura, urticaria, erythroderma, exfoliative dermatitis, lupus erythematosus, lichen planus exanthema, mucocutaneous ocular syndrome, chloracne, leukoderma, pigmentation, melanoleukoderma, alopecia, and deformation/loss of nail.

In addition, we discuss important pesticides that have frequently caused dermal disorders in recent years, with photographs of the lesions in typical cases.

RESULTS

Year-specific Trend and Gender

Data from 394 cases of pesticide-induced dermatitis were collected by our hospital's Department of Dermatology from 1975 to 2000. The number of cases per year was highest in 1975, at 33, and later decreased gradually year by year, with the smallest number registered in 2000, at 3, as shown in Figure 1. This trend may be explained primarily by the fact that dermatitis-causative pesticides came to be increasingly regulated year by year in Japan; in particular, bans on difolatan fungicides in 1989 and salithion, an organophosphorous insecticide, in 1994, were helpful. There may have been other factors, such as improvements in spraying tools and increased awareness of the need for safe use.

By gender, the ratio of male to female cases was 2 to 1: 68% (268 cases) among males and 32% (126 cases) among females. The higher ratio for males may be explained by the fact that pesticide spraying is more frequently done by men in Japan.

Months of Onset

The month-specific numbers of onset of clinical cases are presented in Figure 2. As is evident from patients' complaints, those numbers were large during the months of April to August. This trend is in accord with that of the months in which pesticide spraying was frequently done in the Saku district. Some patients were observed in December, January, and February, but they had been poisoned by pesticide exposures incurred mainly by accident or in attempts at suicide, not in spraying or farm work.

Age Bracket–specific Distribution

The age bracket–specific numbers of victims of pesticide dermatitis are shown in Figure 3. Patients in their 50s accounted for 27%, followed by those in their 60s at 26% and those in their 40s at 21%, indicating that the rate of patients in those three age brackets comes to as high as 74%. Nagano Prefecture,[27] including the Saku district, has continued to record the age distribution of farm workers. In 1985, those in their 60s and older accounted for 48%, while the rate of those in their 40s and 50s stood at 42%. Given ongoing aging, the percentage of those in their 60s and older soared to 70%, and that of those in their 40s and 50s dropped to 25%, in 2000. That said, this trend is in accord with that of generations often engaged in farm work in Japan.

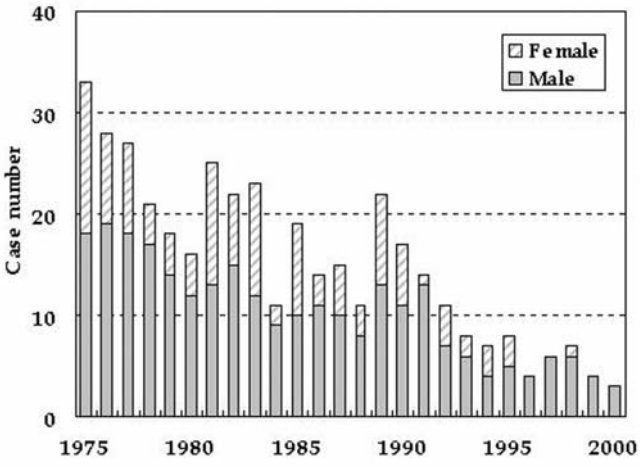

Figure 1—Trends in case numbers of pesticide dermatitis treated at the Department of Dermatology of Saku Central Hospital, Nagano, Japan, 1975–2000.

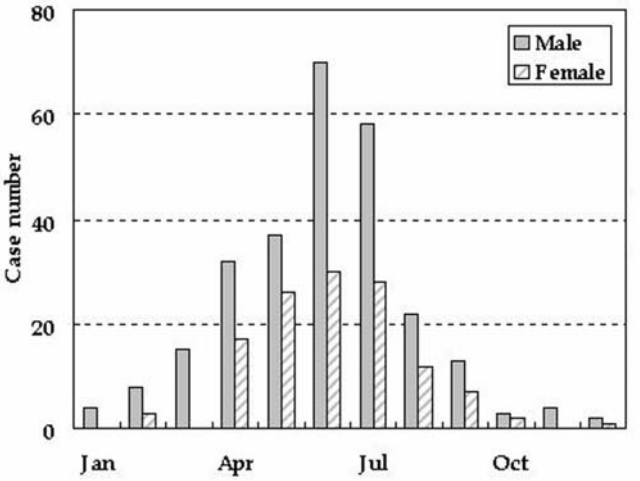

Figure 2—Monthly distribution of case numbers of pesticide dermatitis, 1975–2000.

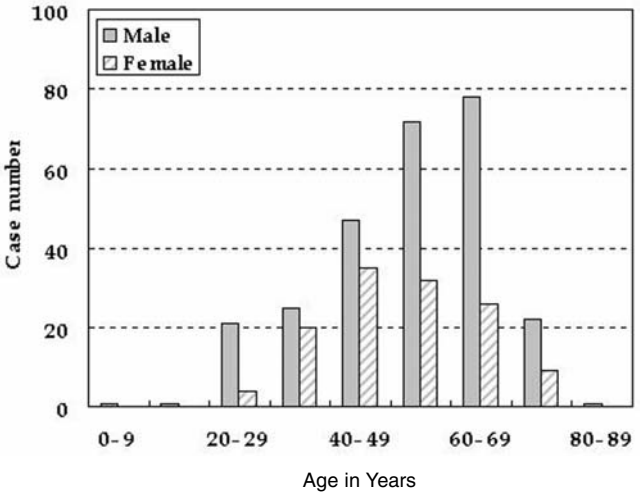

Figure 3—Age distribution of cases of pesticide dermatitis, 1975–2000.

TABLE 1 Numbers of Pesticide-caused Dermatitis Cases Visiting the Department of Dermatology of Saku Central Hospital, Nagano, Japan, by Exposure Condition (1975–2000)*

	Spraying/ Preparing Settling	Re-exposure	Others	Total
Male	197	88	8	293
Female	71	57	4	132
TOTAL	257	145	12	425

*Pesticide exposures of some cases occurred both after initial spraying and after later exposures. These cases were duplicately counted.

TABLE 2 Cases with Previous Experience of Dermatitis Caused by Pesticides

	Yes	No	Total
Male	104	146	250
Female	35	76	111
TOTAL	139	222	361

TABLE 3 Cases with Experience of Contact Dermatitis Caused by Agents Other than Pesticides

	Yes	No	Total
Male	78	172	250
Female	28	83	111
TOTAL	106	250	361

Distribution by Onset Situation

The situations in which onset took place were categorized into 1) "onset during spraying, including preparation and post-spraying work"; 2) "onset during farm work other than spraying"; and 3) "onset in others, such as accidental exposure and misuse." Some of the patients were found to have been twice exposed to pesticides—that is, during both the spraying work and some other type of farm work. They were counted as belonging to the two categories. Hence, their total number is in excess of that of clinical cases. Onset 1 accounted for 63% (257), followed by onset 2 at 35% (145) and onset 3 at 2% (12) (Table 1). Many cases of dermal disorders resulted from contact with pesticides during spraying. However, farm work other than spraying accounted for one third of all cases.

Experience of Past Dermatitis

The numbers of clinical cases who had a history of dermatitis caused by exposures to pesticides and by exposures to other chemicals are shown in Tables 2 and 3, respectively. Of 361 cases surveyed, 139 (40%) had histories of pesticide-induced dermatitis, and 104 (30%) had histories of contact dermatitis caused by chemicals other than pesticides.

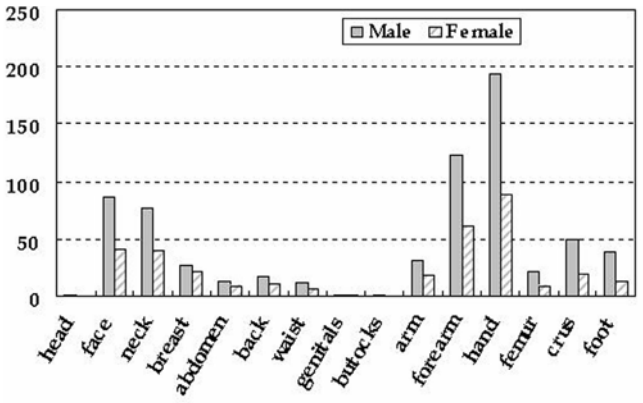

Figure 4—Cases of pesticide dermatitis by affected part in 1975–2000.

Nearly half of the patients with pesticide dermatitis had such histories.

Affected Body Parts

The affected-part–specific numbers of clinical cases are shown in Figure 4. Since some cases had two or more affected body parts, the total number is larger than that of the cases.

The part most frequently affected by pesticide dermatitis was the hand, with 282 cases (27%), followed by the forearm with 188 cases (18%), the face with 127 cases (12%), the neck with 117 cases (11%), and the crus with 70 cases (7%), suggesting that unprotected parts tend to be susceptible to pesticide dermatitis in both spraying and farming work.

Complications of Dermatitis

The symptoms complicating dermatitis are shown in Table 4, along with the causative pesticides. Fever tops the list (6 cases), followed by vomiting/nausea (2 cases), melanoleukoderma (2 cases), numbness, headache, and lymphangitis.

Outcomes

The outcomes of the dermatitis cases are shown in Table 5. Two hundred and eighty patients (72%) were healed, while the symptoms of 69 patients (18%) persisted, and 40 patients (10%) discontinued treatments. Worthy of attention is the fact that pesticide dermatitis could not be cured and became chronic in about 20% of the cases.

Clinical Types

The 394 clinical cases of pesticide dermatitis are classifiable into five clinical types. Acute dermatitis accounted for 54% (206 cases), followed by chronic dermatitis at 21% (80 cases), chemical burns at 17%

TABLE 4 Symptoms/Disorders Coupled with Dermatitis Caused by Pesticide Exposures

Disorders	Cases	Pesticide(s)
Fever	6	Chlornitrofen/dymron, dazomet (3 cases), DDT, paraquat
Nausea /vomiting	2	Nicotine sulfate, paraquat
Melanoleukoderma	2	Calcium polysulfide, methomyl, chlorpyrifos-methyl
Numbness	1	Glyphosate
Headache	1	Paraquat
Lymphangitis	1	DDVP

TABLE 5 Numbers of Pesticide-induced Dermatitis Cases by Outcome

	Healed	Shifted to Chronic Dermatitis	Discontinued Treatment	Total
Male	195	52	21	268
Female	90	17	19	126
Total	285	69	40	394

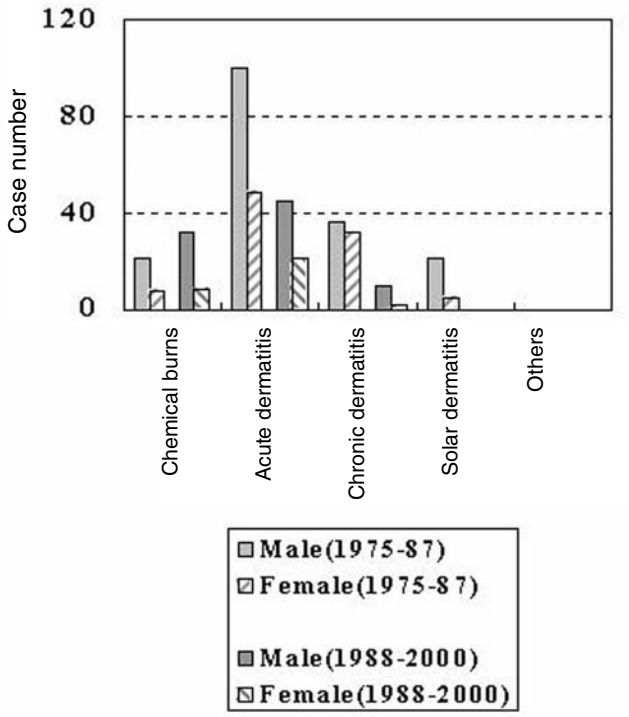

Figure 5—Cases of dermatitis by disorder type in 1975–1987 and 1988–2000.

(65 cases), solar dermatitis at 7% (26 cases), and other types (contact urticaria syndrome, melanoleukoderma, and erythema annulare centrifugum, one case each).

To clarify the characteristics of pesticide dermatitis occurring in recent years, we compared the 272 cases seen from 1975 to 1987 with the 122 cases from 1988 to 2000. We analyzed the clinical cases by both onset year and gender, as shown in Figure 5. We came across 29 cases (11%) of chemical burns in the former period and 41 cases (35%) in the latter. In recent years, there have been signs of a rise in the occurrence of chemical burns. There were 149 cases (55%) of acute dermatitis in the former period and 66 cases (56%) in the latter, with little change between the two periods. As for chronic dermatitis, 68 cases (25%) were registered in the former period, and 12 cases (10%) in the latter. Thus, there are indications that its occurrence has been on the downturn in recent years. Recently, there has been no clinical case of solar dermatitis, though 26 cases (10%) were counted in the former period.

Thus, in the latter half of the 26-year period, the proportion of chemical burns increased, whereas those of chronic and solar dermatitides decreased.

Causative Pesticide

We divided into two periods—1975–1987 and 1988–2000—the pesticides that were considered causative (Tables 6 and 7). Pesticides were considered causative on the basis of developments leading to both onset and subsequent symptoms, or were identified by patch tests.

The organophosphorous pesticides were most often implicated, with 79 cases. The group included dichlorvos (DDVP), salithion, fenitrothion (MEP), leptophos, diazinon, and vamidothion. The second largest group consisted of sulfur products, with 71 cases. This group included zineb, maneb, calcium polysulfide (CaSx), and hydrated sulfur. This group was followed by various fungicides, including anilazine, benomyl, captan, copper sulfate, and copper hydration agent, with 36 cases; organochlorines such as chlorotharonil (TPN), quintozene (PCNB), with 32 cases; soil fumigants, including dazomet and methyl bromide, with 29 cases; herbicides such as paraquat, paraquat/diquat, glyphosate, chloronitrofen (CNP), trifluralin, CNP/dymron, benthiocarb, simetryn, and triforine, with 22 cases; and methomyl as a carbamate with 12 cases.

In a chemical type–specific analysis of causative pesticides, we found many cases of chemical burns—16 cases with CaSx, 12 with dazomet, 10 with methyl bromide, 7 with DDVP, 2 with PCNB, and 2 each with paraquat and paraquat/diquat. All listed pesticides except methyl bromide caused acute dermatitis. Chronic dermatitis was caused by 16 kinds of pesticides. Solar dermatitis was brought about by DDVP, maneb, zineb, methomyl, paraquat, wettable sulfur, and triazin.

A check of 122 cases in 1988–2000 reveals that the causative pesticides included dazomet, DDVP, CaSx, wettable sulfur, methyl bromide, paraquat/diquat, benomyl, PCNB, TPN, and diazinon, in order of numbers of cases. This trend may be explained by the fact that whereas allergic contact dermatitis caused by sensitization-related organophosphorous pesticides

TABLE 6 Numbers of Dermatitis Cases by Causative Pesticide and Clinical Type, 1975–1987

	Number of Cases					
	Chemical Burns	Acute Dermatitis	Chronic Dermatitis	Solar Dermatitis	Others	Total
Dichlorvos	6	19	6	4	—	35
Zineb	—	15	5	2	—	22
Maneb	—	11	5	3	—	19
Salithion	1	6	6	1	—	14
Calcium polysulfide	9	3	—	—	—	12
Pentachloronirobenzene	—	6	5	1	—	12
Chlorothalonil	—	5	6	1	—	12
Benthiocarb/simethrin	—	7	3	—	—	10
Methomyl	—	5	2	2	—	9
Paraquat	2	3	1	2	—	8
Methyl bromide	5	—	—	—	—	5
Dazomet	1	4	—	—	—	5
Fenitrothion	1	4	—	—	—	5
Anilazine	—	1	2	2	—	5
Triforine	—	4	1	—	—	5
Captan	—	3	—	—	—	3
Leptophos	—	2	1	—	—	3
Chlornitrofen	—	3	—	—	—	3
Trifluralin	—	3	—	—	—	3

decreased, highly irritant dermatitis resulting from exposures to soil fumigants and herbicides increased.

DISCUSSION

The number of effective chemical ingredients contained in pesticides and registered in Japan today stands at approximately 460, whereas the number of products for sale stands at approximately 6,000 in kind.[28] There is concern that many dermal disorders occur on Japanese farms, where many kinds of pesticides are used in large quantities.

Clinical Types of Dermatitis Induced by Pesticides

We propose a classification of pesticide-induced dermatitides based on the relationships between the onset mechanism and the clinical types of dermatitis, as shown in Figure 6, on the basis of our experience in 394 clinical cases.

As shown in the left side of the figure, the onset mechanisms of dermal disorders resulting from pesticide exposures are classified in five categories, irritant contact dermatitis (including chemical burns), allergic contact dermatitis, phototoxic contact dermatitis,

TABLE 7 Numbers of Dermatitis Cases by Causative Pesticide and Clinical Type, 1988–2000

	Number of Cases					
	Chemical Burns	Acute Dermatitis	Chronic Dermatitis	Solar Dermatitis	Others	Total
Dazomet	12	4	—	—	—	16
Calcium polysulfide	9	1	—	—	1	11
Dichlorvos	1	6	3	—	—	10
Benomyl	—	5	1	—	—	6
Wettable sulfur	—	4	2	—	—	6
Chlorothalonil	—	2	2	—	1	5
Methyl bromide	5	—	—	—	—	5
Paraquat/diquat	2	2	1	—	—	5
Diazinon	1	3	—	—	—	4
Quintozene	2	1	1	—	—	4
Vamidothion	—	4	—	—	—	4
Chlornitrofen/dymron	—	2	1	—	—	3
Copper sulfate	—	2	1	—	—	3
Copper sulfate, basic	—	3	—	—	—	3
Glyphosate	1	2	—	—	—	3
Methomyl	1	2	—	—	—	3
Zineb	1	2	—	—	—	3
Salithion	—	2	—	—	—	2

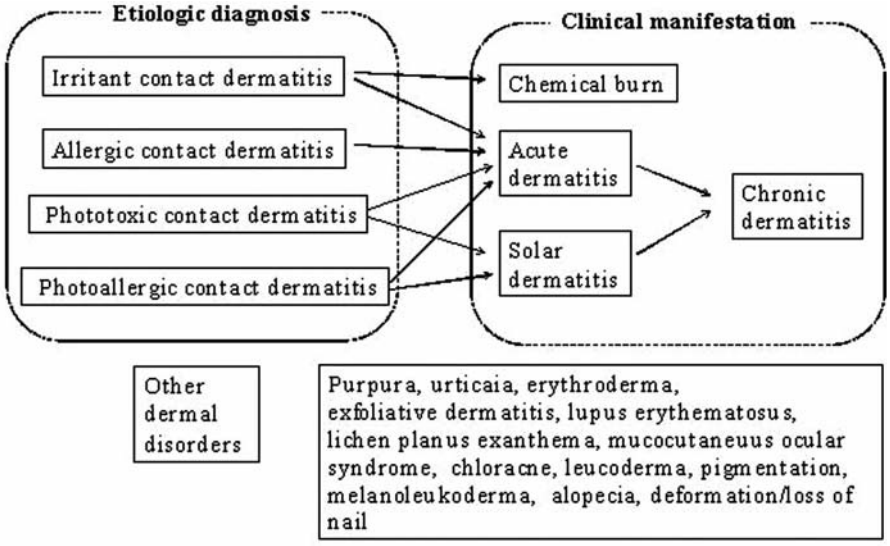

Figure 6—Etiologic diagnoses and clinical manifestations of dermatitis cases caused by pesticides in the Saku area.

photoallergic contact dermatitis, and other dermal disorders.

As indicated in the right side of Figure 6, pesticide dermatitis is classified into five clinical types: chemical burn, acute dermatitis, solar dermatitis, chronic dermatitis, and other.

The chemical burn type is an inflammation that occurs as a highly toxic pesticide adheres to the skin and the epidermis and/or skin is directly eroded or destroyed.

Acute dermatitis is either a primary irritation in response to contact with a pesticide or an allergy-related contact dermatitis. The primary irritation occurs when the skin is directly disordered by pesticide-caused irritation. Anyone who contacts the pesticide in question may fall victim to this disorder, and the affected part may turn red and swell, sometimes with bullae and erosion.

Allergic dermatitis occurs among persons in whom sensitization is developed to a pesticide as an allergen. The patient experiences itching and erythema, swelling, papules, and blisters.

Solar dermatitis results from phototoxic and/or photoallergic factors that feature pesticides. With light exposure, erythema and scale, and sometimes papules and small vesicles, appear after the spraying of pesticides under intense sunlight irradiation.

Chronic dermatitis is acute in the spring, when farm work begins, with recurrent healing and exacerbation until autumn. The hand is a main affected part, and the disorders consist of erythema, hypertrophy or lichenification, scale, crust, and crack. Mainly, pesticides cause those disorders, but in addition many other stimulants, such as chemical fertilizer, vegetable juice, soil, sunlight, and other materials in everyday life may cause contact dermatitis with irritant and/or allergic characteristics blended.

Other dermal disorders caused by pesticides, listed in the lower part of Figure 6, are relatively rare.

Main Pesticides Causing Dermatitis in Recent Years

1. Chemical burns from calcium polysulfide. The majority of calcium polysulfide (CaSx) products are a dark reddish brown liquid and include 22% active ingredient. This chemical has for many years been broadly used as an insecticide and a fungicide in the early spring. In addition, spraying this agent before the harvesting of mandarin oranges accelerates their coloration and prolongs their preservation. The main cause of injury is breathing obstruction by sulfur.

The toxicity caused by ingestion is not so severe, and this agent is categorized as moderately hazardous, but it severely irritates the skin and has strong alkalinity. When it adheres to the skin, it causes deep alkaline erosion, leaving a milky-white alkali crust to stick to the affected part. Usually, the affected parts include the face, neck, forearm, hand, leg, and foot. In particular, a deep ulcer, albeit localized and small in scope, is formed when mechanical friction is added to abrasion by clothes soaked with the liquid product. There are many cases in which an ulcer appears on the knee or at the edges of boots, where strong friction occurs during walking. Figure 7A shows a chemical burn from CaSx.

If the skin gets wet, it is necessary to immediately wash it with water.[29,30] We usually treat the affected parts with antibiotic ointment, but there are cases in which debridement and dermatoplasty must be performed, as shown in Figure 7B.

2. Dermatitis from dazomet. The dazomet fumigant for the soil is a white fine-grain product containing dazomet in concentrations up to 98%. In wet soils, the fumigant is applied and the soil is covered with vinyl sheets for seven to ten days. In drier soils, the fumigant is mixed into the soil, which is then irrigated. In contact with ground or irrigation water, the chemical is degraded to methyl isocyanate and works as a combination of fungicide, nematocide, and herbicide in the soil.

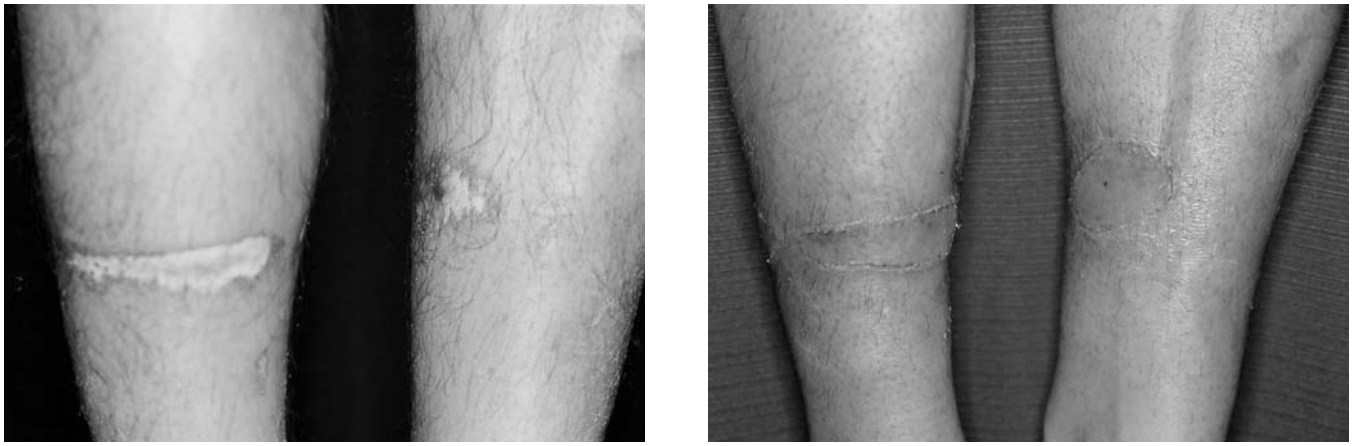

Figure 7—Chemical burns from calcium polysulfide. In mid-April, a 30-year-old man sprayed calcium polysulfide over peach trees with a power sprayer for four hours. His pants got wet with the solution, and his sural part was rubbed with the edge of one of his boots, causing deep alkaline erosion and then necrosis, as shown in Photo A. We treated the affected region with steroid ointment for more than a month, but the eroded part did not heal. In early June, a month and a half later, we performed dermatoplasty, as shown in Photo B.

Falling into boots during the spraying work, this powder will degrade with sweat and cause dermatitis. Especially if the product soaks into the socks and the boots cause friction, the leg from knee to instep will be affected with strong flare and swelling, causing a large-scale bulla as shown in Figure 8. This pesticide has caused more dermatitis in recent years than any other, so strict care must be exercised in using it. The parts likely to be affected are the face, neck, forearm, hand, leg, and foot. The resulting disorders, in the category of Grade II burns, may heal without scar in about two weeks.

3. Chemical burns from methyl bromide. The methyl bromide product is a colorless volatile liquid that includes 98.5–99.5% of methyl bromide. It is used in large quantities to sterilize the soil of farm fields, seedbeds, and greenhouses. It is also used in large quantities for stockyard fumigation of imported grain products and wood materials. Categorized as highly hazardous, this agent causes acute intoxication among storehouse workers. Furthermore, this chemical depletes the ozone layer, and the Japanese Ministry of Labor decided to work for a full ban step by step beginning in 2001.

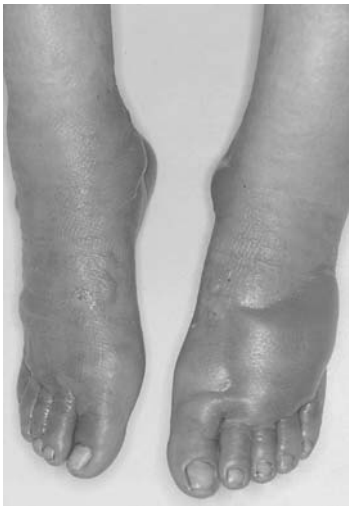

Figure 8—Chemical burns from dazomet. In mid-June, a 37-year-old woman sprayed the powder product of dazomet, some of which entered into her boots. In the evening, her insteps turned red and swelled, and the affected parts turned into large-sized bullas at night. We treated the lesions as burns and they healed within two weeks.

Cover with a plastic sheet the soil to be sterilized and then open a can of fumigant, and methyl bromide gas will spout out and fumigate the soil. If the gas happens to touch the skin, the affected part will turn red, swell with a feeling of urtication, and produce a bulla-like burn symptom. Because of the nature of the mechanism, the affected part is the hand in almost every case.

The treatment of the burn is usually successful, leaving no scar. Consequently, this burn is classified as second degree with bulla and erosion. A lesion from a chemical burn by methyl bromide is shown in Figure 9.

The chlorpicrin fumigant commonly used for soil causes the same chemical burns as methyl bromide. In addition, the harsh odor of this chemical stimulates the lacrimal glands, and exposure may be fatal.

4. *Dermatitis from organophosphates.* The organophosphates are more numerous than any other type of pesticide. They are used as insecticides, fungicides, and herbicides. They are responsible for many cases of dermatitis, which come in every clinical type. Chemical burns occur at places to which the undiluted solution adheres after exposures to dichlorvos (DDVP), salithion, or fenitrothion (MEP). Figure 10 shows a chemical burn by DDVP. The majority of cases of dermatitis with organophosphorous pesticides are allergy-related.

In 1984, we ran patch tests to clarify the incidence of dermatitis from the use of pesticides.[31] The pesticides

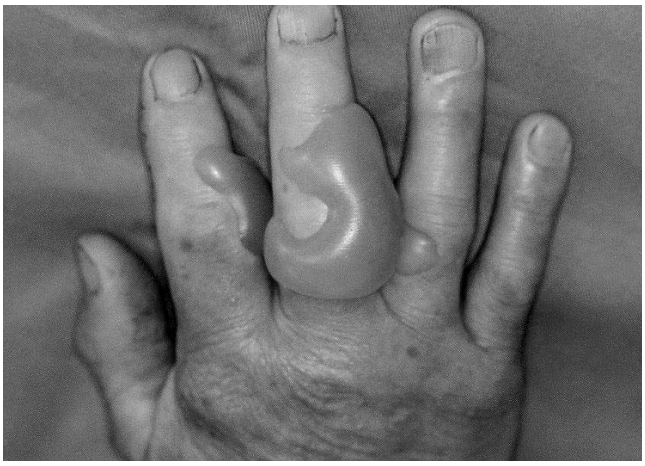

Figure 9—Chemical burns from methyl bromide. In late September, a 61-year-old man opened a can of methyl bromide product in a tunnel covered with vinyl sheets. The gas invaded his gloves through pin holes. The index, middle, and ring fingers of his right hand had large bullae, which took two weeks to heal.

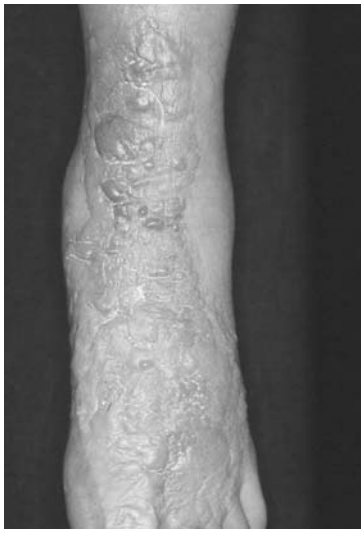

Figure 10—Chemical burns from dichlorvos. In late July, a 23-year-old man dropped an uncapped bottle in a mixing process. The instep of his left leg got wet with a stock solution of dichlorvos emulsion. The next day, the instep turned red and swelled with pain, and the affected part turned into bullae. He was treated with steroid ointment and oralsteroid, and the lesion healed a week later.

were diluted with petroleum jelly to the levels at which they were put to everyday use. The subjects were patched with pesticides for 48 hours. One hour later, the patches were removed to check dermal reactions. Erythema, edema, and/or severer reactions were considered positive under Japan's assessment criteria. It was confirmed in patch tests that 30 (19%) of 156 farmers had positive reactions to leptophos; 132 (17%) of 783 farmers, to DDVP; 47 (13%) of 371 farmers, to MEP; 58 (11%) of 535 farmers, to diazinon; and 74 (11%) of 670 farmers, to salithion. Figure 11 shows the allergic dermatitis of the patient whose burn is shown in Figure 10. In recent years there have been signs of a decline in the incidence of dermatitis caused by organophosphates.

5. Dermatitis from paraquat. Paraquat products used in the 1960s and 1970s contained 24% or 38% paraquat dichloride. But as there was no appropriate treatment method for poisoning from suicidal and accidental ingestion, there appeared a lot of death cases. Consequently, restrictions were imposed on the use of these products, and low-concentration products containing 5% paraquat dichloride and 7% diquat dibromide were put on sale in 1986. The new products, which came out under the brand names of Preeglox L™ and Myzet™, were water-soluble liquids of dark bluish green and categorized as extremely hazardous in Japan.

The weed-control mechanism of paraquat is as follows. The peroxide produced in a process oxidized by atmospheric oxygen suddenly destroys the plant cell wet with this product. It withers and dies. Light is necessary for this mechanism.

This chemical is highly irritant to the skin and eyes, and if the skin gets wet, the affected part will turn red, swell, and form red ulceration and bullae. This product is also irritant to the mucous membrane. If ingested, erosion and ulcers will begin to form a few hours later in the mouth and the gullet. Figure 12 illustrates chemical burns caused by a paraquat product.

In addition, Terasaki[32] and Amano and Matsunaka[33] report cases with vesicles, sores, and scrotal involvement, when the liquid product in a concentration for normal use has soaked into clothes. The dermal disorders caused by paraquat seem to worsen when mechanical friction is added to the adhesive liquid product. The parts most often affected by the resulting dermal disorders are the face, neck, forearm, and hand. Our series also included five cases of dermatitis arising after spraying with the diluted liquid of a 5% paraquat + 7% diquat product.

Four deaths from respiratory failure after the skin had been broadly wetted with paraquat products, and vesicles and sores had appeared, have been reported.[33] There also are reports of cases in which each time spraying was done, more of the sprayed chemical infiltrated the skin, eventually resulting in the sprayers' deaths.[34,35] Thus, where chemical burns are caused by paraquat, the affected skin absorbs the liquid, potentially leading to fatal systemic poisoning.[35]

In the event that this chemical is the suspected cause of dermatitis the important thing is to immediately perform a qualitative urinanalysis and, if the test is positive, systemic lifesaving measures must be taken.

6. *Dermatitis from chlorotharonil.* Chlorotharonil (TCPN), an organochlorine fungicide, contains 4–40% of active ingredient, comes in hydrate, powder, and

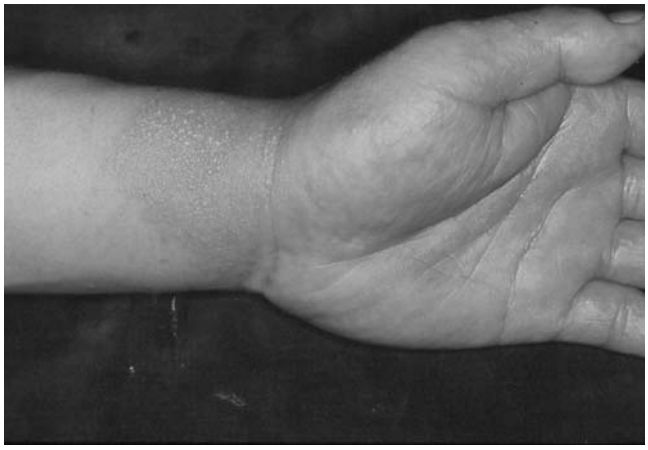

Figure 11—Acute dermatitis with dichlorvos. The man whose burn is shown in Figure 10 diluted and sprayed dichlorvos (DDVP) emulsion in early June of the following year, from which his hand and forearm got wet. The next day, his arm and hand turned red and swelled, with the appearance of many vesicles and a severe ulcer. We diagnosed contact dermatitis. It healed a week later. In patch tests, there are cases where even the 50,000-times dilution of DDVP comes out with a "++" reaction. The patient seemed to have been sensitized by the chemical burns in the preceding year and to develop allergy-related contact dermatitis.

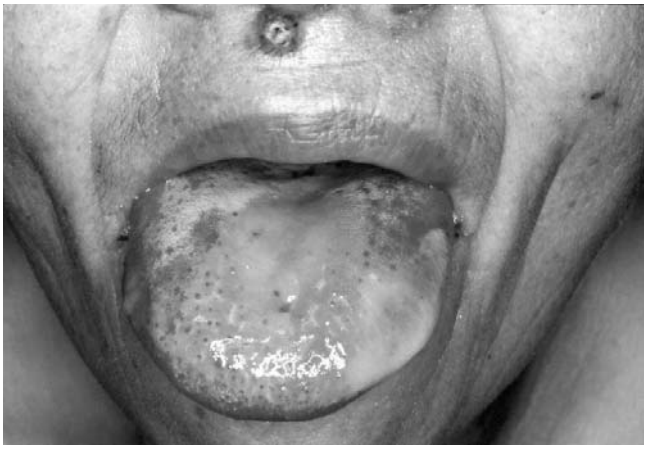

Figure 12—Chemical burns from paraquat. In late August, a 70-year-old woman stumbled as she tried to take from a shelf a bottle that contained a solution of 24% paraquat product. Its cap accidentally opened with the solution splashed over her head, face, and body. The next day, she had a sore in her mouth and a milky-white ulcer appeared on the back of her tongue. The stock solution of paraquat seemed to have flowed into her mouth. Though she had a fever and her appetite fell off, qualitative urinalysis was negative. The lesion healed a week later.

fumigant form, and is used as a fungicide for vegetables and fruit trees and as a fumigant in greenhouses. The oral toxicity of TCPN is moderate but it has strong irritant properties and frequently causes acute and chronic dermatitis.

We ran patch tests on 766 farmers with a concentration at 0.15% TCPN in the same method described for organophosphates,[31] and 338 persons (43.6%) were found positive under Japan's assessment criteria. This result indicates that TCPN is a strong irritant pesticide, as was reported by Flannigan et al.[36]

We came across a patient with allergic contact urticaria syndrome in 1990. The patient, a 43-year-old man, had developed urticaria each time he had sprayed TCPN in the preceding ten years. He had had urticaria all over his body and had experienced shock with systemic malaise, weak pulse, dyspnea, and facial pallor after spraying TCPN twice in the spring of 1987. He visited a doctor in his neighborhood and was later admitted to our hospital. A patch test confirmed that his urticarial reaction was positive even when the TCPN solution was diluted 500,000 times. This chemical causes a severe reaction even when the quantity in the spray is very small. Penagos et al.[37] reported TCPN as an allergenic pesticide, and Matsushita et al.[38] also reported a photoallergic case resulting from exposure to this agent.

7. Dermatitis from glyphosate. Glyphosate is an amino acid herbicide, 41% of which consists of glyphosate isopropylamine. Usually sprayed during the growth period of weeds, this product is distinguished by the fact that, absorbed by the stem and leaves, it moves down to the roots to wither the weeds. Glyphosate has been used in large quantities in recent years because its weed-control spectrum is extremely wide. We diagnosed a case in which the liquid product containing this agent had been soaked up by the seams of a shoe and caused acute dermatitis. It is possible that glyphosate-induced dermatitis will occur more frequently in the future, as the distribution of this chemical is increasing.

8. Dermatitis from quintozene. The quintozene (PCNB) product is a powdered agent that contains pentachloronitrobenzene in concentrations of up to 20%. It is a soil fungicide used to prevent the root-knot disease of cabbage and Chinese cabbage. This product is usually sprayed evenly and mixed with soil by farm tractor or hoe. In boots and gloves, this product dissolves with sweat and irritates the skin. The wetted part turns red, swells, and sometimes forms a large vesicle. In most cases, this product causes dermatitis on such parts as the face, neck, upper arm, forearm, hand, leg, and foot.

CONCLUSIONS

Statistical data derived from 394 cases of dermatitis caused by pesticide exposures were collected by the Department of Dermatology, Saku Central Hospital. The number of clinical cases gradually decreased from 1975 to 2000, which may be attributable to the phase-

out of certain dermatitis-causating pesticides, such as difolatan fungicide in 1989, and salithion, an organophosphorous insecticide, in 1994. Improvements in spraying tools and an increased awareness of the need for safe use may also have been factors. The cases of chronic and solar dermatitides decreased, which may be explained by reductions in the use of allergic or photosensitive pesticides such as sulfur agents and organophosphates. On the other hand, the incidences of chemical burns with irritant pesticides, including calcium polysulfide, dazomet, methyl bromide, chlorpicrin, organophosphorus, paraqat/diquat, glyphosate, and quintozene, increased. The chemical burn from calcium polysulfide is the severest, with deep alkaline erosions, which may sometimes need debridement and dermatoplasty.

Low-toxicity and low-irritant pesticides have come to play a major role in recent years, while serious acute intoxications have decreased, but care must be exercised in the use of pesticides, which still cause dermatitis.

The authors' deep appreciation goes to doctors and paramedic coworkers at the Saku Central Hospital's Department of Dermatology, especially to Dr. Yukiko Andoh, Dr. Misae Oguchi, and Dr. Shiho Seki.

References

1. Matsushita T, Nomura S, Wakatsuki T. Epidemiology of contact dermatitis from pesticides in Japan. Contact Dermatitis. 1980; 6:255-9.
2. Matsushita T, Aoyama K, Yoshimi K, Fujita Y, Ueda A. Allergic contact dermatitis from organophosphorus insecticides. Ind Health. 1985;23:145-53.
3. Wang Z-Y, Matushita T, Aoyama K, et al. Statistical analyses of clinical cases of skin lesions from agricultural chemicals in Japanese farmers, 1982–1989. J Jap Assoc Rural Med. 1991; 40:909-16.
4. Ueda A, Aoyama K, Manda F, Ueda T, Kawahara Y. Delayed-type allergenicity of triforine (Saprol). Contact Dermatitis. 1994; 31:140-5.
5. Higo A, Ohtake N, Saruwatari K, Kanzaki T. Photoallergic contact dermatitis from mancozeb, an agricultural fungicide. Contact Dermatitis. 1996;35:183.
6. Obama K. Studies on allergic skin disease caused by pesticides in citrus growers: field survey study and animal experiments. Med J Kagoshima Univ. 1996;48:13-22.
7. Nakamura M, Miyachi Y. Airborne contact dermatitis caused by the pesticide acephate. Contact Dermatitis. 2002;47:121-2.
8. Nakamura M, Miyachi Y. Airborne photocontact dermatitis due to the insecticide phoxim. Contact Dermatitis. 2003;49:105-6.
9. Nishioka K. Dermatopathy due to the chemical substance. 43. Detailed explanation. 36. Contact dermatitis due to the agricultural chemicals. J Med Pharm. 2003;39:1190-7. [In Japanese]
10. Hayakawa R, Sugiura M. Occupational contact dermatitis. Allergy/Immunol. 2004;11:628-35. [In Japanese]
11. Ishikawa H, Miura A. Two cases of chemical burns due to agricultural chemicals. J Environ Dermatol. 2005;12:101-4. [In Japanese]
12. Shao Y-H, Guo Y-L, Yeh W-Y, Chen C-J, Chen C-W. Prevalence of self-reported work-related skin conditions in Taiwanese working Population. J Occup Health. 2001;43:238-42
13. Dannaker CJ, Maibach HI, O'Malley M. Contact urticaria and anaphylaxis to the fungicide chlorothalonil. Cutis. 1993;52: 312-5.
14. Van Ginkel CJ, Sabapathy NN. Allergic contact dermatitis from the newly introduced fungicide fluazinam. Contact Dermatitis. 1995;32:160-2.
15. Koch P. Occupational allergic contact dermatitis and airborne contact dermatitis from 5 fungicides in a vineyard worker. Cross-reactions between fungicides of the dithiocarbamate group. Contact Dermatitis. 1996;34:324-9
16. Guo YL, Wang BJ, Lee CC, Wang JD. Prevalence of dermatoses and skin sensitisation associated with use of pesticides in fruit farmers of southern Taiwan. Occup Environ Med. 1996;53:427-31.
17. O'Malley MA. Skin reactions to pesticides. Occup Med. 1997; 12:327-45.
18. Cole DC, Carpio F, Math JJ, Leon N. Dermatitis in Ecuadorean farm workers. Contact Dermatitis. 1997;37:1-8
19. Rademaker M. Occupational contact dermatitis among New Zealand farmers. Australas J Dermatol. 1998;39:164-7.
20. Mark KA, Brancaccio RR, Soter NA, Cohen DE. Allergic contact and photoallergic contact dermatitis to plant and pesticide allergens. Arch Dermatol. 1999;135:67-70.
21. Bener A, Lestringant GG, Beshwari MM, Pasha MA. Respiratory symptoms, skin disorders and serum IgE levels in farm workers. Allerg Immunol (Paris). 1999;31:52-6.
22. Amer M, Metwalli M, Abu el-Magd Y. Skin diseases and enzymatic antioxidant activity among workers exposed to pesticides. East Mediterr Health J. 2002;8:363-73.
23. Penagos HG. Contact dermatitis caused by pesticides among banana plantation workers in Panama. Int J Occup Environ Health. 2002;8:14-8.
24. Penagos H, Ruepert C, Partanen T, Wesseling C. Pesticide patch test series for the assessment of allergic contact dermatitis among banana plantation workers in Panama. Dermatitis. 2004;15:137-45.
25. Arcury TA, Quandt SA, Mellen BG. An exploratory analysis of occupational skin disease among Latino migrant and seasonal farmworkers in North Carolina. J Agric Saf Health. 2003;9:221-32.
26. Spiewak R. Pesticides as a cause of occupational skin diseases in farmers. Ann Agric Environ Med. 2001;8:1-5.
27. Nagano Prefecture. Outline of Nagano prefectural agriculture, 2006. <http://www.pref.nagano.jp/nousei/nousei/18naganoagri.pdf>. [In Japanese]
28. Agricultural Chemical Inspection Station, Bulletin of the Agricultural Chemical Inspection Station. Kodaira, Tokyo, 2005; 3-4. <http://www.acis.go.jp/acis/syohou/syohou45.pdf>. [In Japanese]
29. Morigami T, Noda M, Katsuura J, Matsuoka Y, Sadahira C. Chemical burns with calcium polysulfide. Diag Treat Dermatol. 2004;26:731-4. [In Japanese]
30. Udono M. Chemical burns cases visited our hospital. Diag Treat Dermatol. 2004;26:757-65. [In Japanese]
31. Horiuchi N. Contact dermatitis caused by pesticide. Nishinihon J Dermatol. 1987;49:228-35. [In Japanese]
32. Terasaki T. Paraquat dermatitis. Diag Treat Dermatol. 1985; 7:823-4. [In Japanese]
33. Amano M, Matsunaka N. Scrotum erosion with herbicide paraquat. Diag Treat Dermatol. 1987;9:837-40. [In Japanese]
34. Kishimoto T, Fujioka H, Yamato I, Ozaki S, Ohka M. Lethal paraquat poisoning caused by spraying in a vinyl greenhouse of causing pulmonary fibrosis with hepatorenal dysfunction. J Jap Resp Soc. 1998;36:347-52. [In Japanese]
35. Wesseling C, van Wendel de Joode B, Ruepert C, et al. Paraquat in developing countries. Int J Occup Environ Health. 2001; 7:275-86.
36. Flannigan SA, Tucker SB, Calderon V Jr. Irritant dermatitis from tetrachloroisophthalonitrile. Contact Dermatitis. 1986; 14:258-9.
37. Penagos H, Jimenez V, Fallas V, O'Malley M, Maibach HI. Chlorothalonil, a possible cause of erythema dyschromicum perstans (ashy dermatitis). Contact Dermatitis. 1996;35:214-8.
38. Matsushita S, Kanekura T, Saruwatari K, Kanzaki T. Photoallergic contact dermatitis due to daconil. Contact Dermatitis. 1996; 35:115-6.