Status and Suggestions of the Pesticide Use in the Protected Vegetable Fields in Shandong Province

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Abstract This paper briefly introduced the issues of food safety and environmental pollution caused by pesticide residues in protected vegetables, discussed the status and problems of pesticide use in the protected vegetables in Shandong Province, and analyzed the main factors leading to the pesticide residues, including the low education of most farmers, lack of correct identification of diseases and insect pests, use of pesticides based on personal experience, pesticide preparation by bare hands, large dose of pesticide, frequent application, pesticide spraying without protection, uneven spraying, leakage of pesticide from the sprayers, *etc.*. Finally, based on the vegetable planting features and advantages in Shandong Province, some suggestions were proposed for references, such as, to enhance the monitoring of pesticide residue, to improve the educational level of farmers and to scentifically use the pesticide.

Key words Protected vegetables, Use of pesticide, Suggestions

With people's growing demands for vegetables in recent years, the vegetable industry has become an industry with distinctive features, especially the vegetable industry in the protected areas of Shandong Province which develops fastly and greatly and has presented its own advantages. According to the statistics, the cultivation area of vegetables in whole Shandong Province has improved from 393 500 hm^2 in 1991 to 1 770 800 hm^2 in 2010, and the total output has increased from 0. 150 3 billion t to 0. 903 1 billion t. Among them, there are 220 000 hm^2 sunlight greenhouse, 267 000 hm^2 plastic greenhouse, 380 000 hm^2 medium or small-sized arch shed, and the total area of facility vegetables is maintained at about 867 000 hm^2[1-4]. In only 2009, the planted area of vegetables (including melons) in whole Shandong Province is 2.03 million hm^2, with an total output of 0. 102 billion t, respectively accounting for about 11% and 16.6% of that in whole China; the total output value is 152.74 billion yuan, accounting for about 47.4% of total agricultural output value; the earning form the export reaches up to 2.01 billion dollar, accounting for about 31.2% of that in Whole China; the area of facility vegetables is 86.78 hm^2, accounting for more than 20% of that in China. The vegetable industry has become a major industry in Shandong Province to increase the farmers' incomes, and plays an important role in agricultural production in Shandong Province.

Speaking of the vegetable industry, we have to mention pesticide, which plays an irreplaceable position in agricultural production. With the purpose of reducing or eliminating pests and diseases, the pesticide guarantees the production of safe crops. With the improving living standards, the people's requirements for green food are improving. Therefore, a great variety of crops and various modes of planting requires advanced concept of advanced agricultural production and improvement of pesticides. According to statistics, about one million t pesticides are consumed in China, which prevent the pests and diseases in more than 0.3 billion hm^2 area. In 2007, there are over 1 800 pesticide manufacturers, among which there are 1 334 pesticide formulation production enterprises, producing about 1.6 t pesticide formulations every year, some of which are also exported to foreign countries, creating nearly 20 billion yuan annual output value. China has become the second largest pesticide production country. By the end of 2009, the number of pesticide manufacturers has increased to over 2 000 with more than two million t produced, 0.5 million t exported and 0.326 million t used, which all rank the first in whole world. At present, the production amount of pesticides in China is still rising. According to the National Bureau of Statistics, the total production of pesticides in China was increased by 15.7% during January and September, 2011. According to the analysis of the plant protection stations in 31 provinces (districts and cities), the total demand for pesticide in China was 0.313 6 billion t in 2012, which increased by 2.48% than in the previous years[5]. However, there are a great variety of pesticides on market and the pesticide market is in chaotic, which brings serious damages to the production and sales of pesticides. In this paper, the problems caused by the misuse of pesticides will be discussed, and some suggestions will be proposed on the right use of pesticides for vegetables in Shandong Province so as to provide references for the future study.

1 Problems caused by the misuse of pesticides in the protected vegetable fields

At present, the use of pesticides is an important means to reduce

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the occurrence frequency of pests and diseases, however only very few pesticides sprayed can realize their purpose of controlling pests and diseases. According to the previous studies, about 25% – 50% of the pesticides sprayed with sprayers leave on the leaves, less than 1% are left on the target pests and disease, while only 0.03% of the pesticide can play a preventive effect [5]. Thus, it can be concluded that the utilization efficiency of pesticides is extremely low, and a majority of pesticides are lost to the environment, producing negative impact, such as human and livestock poisoning and environmental pollution.

1.1 The issues of food safety resulted from the pesticide residue in vegetables Pesticide residue refers to the residue of pesticides inside or on the surface of vegetables, including the pesticides, their metabolites and poisoned impurities, *etc.* [6]. Few intake of pesticide residue in vegetables will cause headache, dizzy, weakness, sickness and listlessness; while a great intake will result in serious symptoms, such as asthenia, vomiting, diarrhea, and dismay; in severe cases, the sufferers may have convulsions, coma, heart failure or even death. The accumulation of pesticide residue to a certain amount will lead to some diseases, such as male infertility[7].

With the improving structure of vegetables and the consumers' increasing demands for safe vegetables, the cases of food poisoning caused by pesticide residue in vegetables frequently occurs. Moreover, due to the fact that the pesticide residue in part of the agro-products has exceeded the international standards, the export of China agro-products faces great obstacles, which, to some extent, seriously influences the export and national economy of China. The food safety issues resulted from the pesticide residue call for immediate actions.

The pesticide residue in vegetables is mainly caused by two factors, namely, the use of highly toxic and high-residue pesticides, as well as the excessive use of regular pesticides. With the improving management of pesticide market in China, the toxicity of pesticide is receiving more and more attention and transforming into low-toxic or even non-toxic pesticides. However, compared to the efficient effect and low costs of highly toxic and high-toxic pesticides, the low-toxic pesticides are generally expensive with short duration and frequently utilization. Thus, in order to save time and labors, the farmers usually choose those with high efficiency but low price. Some pesticide dealers still sell those highly toxic pesticides which have been strictly prohibited by the national laws, as a result, some vegetables containing highly toxic pesticide appear on the food tables. For example, according to a sample test of the vegetables on market in Beijing, of the 150 samples selected, as high as 80% were detected to contain organic phosphor and carbamate pesticides, and more than 10% exceeded the standards. According to the investigation results of the pesticide residue in vegetables in Jinan City, there were about 24 types of pesticides left on the vegetables, 45.8% are prohibited pesticide[8]. It was reported that the pesticide residue in leaf and root vegetables in Mianyang was the highest, and only about 48.15% and 58.33% meet the standards, the main pesticide is methyl parathion[9]. The pesticide residue in the vegetables of Taiyuan is also very serious, and the pesticide of organic phosphor is the main type. In 2011, about six and ten people got poisoned by eating the Chinese chive in Qingdao and Henan, and the residue of pesticide in 1 000 kg Chinese chive reached as high as 30% [10-11]. On the other hand, some farmers increase both the application doses and frequency of pesticides or compound various pesticides together without any technical guidance, which, as a result, also leads to the excessive pesticide residue in vegetables.

1.2 Environmental pollution caused by the pesticides in vegetable greenhouse With the development of high-efficient and low-toxic pesticides and the improvement of labor productivity in recent years, the pesticides are playing a leading role in agricultural harvest, but the studies on pesticide application theories and measures are still insufficient. The farmers' understanding of pesticide use is limited to the level of dose and formulation as well as the technical level of large dose and large droplet spray technique. The utilization of pesticide is extremely inefficient. According to related studies, only about 20% – 30% of the sprayed pesticide is left on the crops, while the rest is lost to the surrounding environment. Based on related statistics, 20% – 30% of the applied pesticide is attached to the crops, 30% – 50% drops to the ground, while 5% – 20% disperses in the air, which is washed down by the rainwater to pollute local soil and groundwater, producing inestimable loss and harms to the living environment of local people[12]. The air and water pollution in the greenhouse is detrimental to some beneficial organisms, reduces local biological diversity and even leads to human and livestock poisoning. It is reported that about fifty million people in Indonesia suffer from chronic pesticide poisoning; the incidence about people get poisoned by eating pesticide polluted vegetables sometimes occur; in the early 1990s, 24 cases of pesticide polluted vegetables occurred in Guangzhou, which get 312 people poisoned; 156 people were poisoned by eating the methamidophos polluted vegetables in two cases, the similar poisoning cases by eating pesticide polluted vegetables also occurred in Shandong and Yunnan Provinces, where 734 people got poisoned and one was dead. With the increasing varieties of pesticides and their improving doses, the poisoning caused by pesticide pollution still occurs. It is reported by WHO that about two million people get poisoned by the pesticide in developing countries every year due to the farmers' lack of scientific knowledge and safety measures. About 40 000 people are dead, which means that 28 people are poisoned in every 10 min, and one people is dead every 17 min, which, however, does not include the stillborn foetus, cancer and miscarriage caused by pesticide pollution. According to the investigation in 68 countries, 93% of acutely poisoned people are caused by the pesticides of organic chloride, organic phosphor and mercury[13-15].

The pesticides pollution to vegetable greenhouses in the protected areas is mainly caused by two reasons. The first reason is the farmers'blindness of applying pesticides. The farmers apply the

pesticides regardless of the time and dose, and they even mix different pesticides, which produce greater harms and toxicity to local environment than any single pesticide[16]; the other reason is the farmers' backward application technique, most farmers still use the manual sprayer, which is extremely inefficient. According to related studies, the leakage of pesticide frequently occurs by using the manual sprayer, which, in a long time, will bring extremely serious harms to local environment[17-18].

2 The pesticide use status for vegetables in the protected areas of Shandong Province

(1) The farmers' identification of pests and use of pesticides are purely based on their personal experience rather than technical guidance. According to the investigation on one hundred rural households in Sunjiaji Village, Donghegou Village, Hanjia Village, Dingjia Village and Yuanshui Village nearby Shouguang, Shandong Province in 2011, 16% of them only have primary school education or below, 71% have middle school education, 12% have high school education, while only 1% have college education, which indicates that the greenhouse farmers generally have a low educational level, and their knowledge about vegetable cultivation and pests control is purely based on their personal experience. Although they can identify some common pests and disease, they have no idea about the causes to their occurrence. As a result, some prevent fungi diseases with the pesticides for bacteria diseases, while others use the leave diseases pesticides to prevent the root disease, which not only increases the cost and misses the best timing of pests and diseases control, but also even causes great harms to vegetables. For example, the disease of yellow leaf curl happened in Shandong Province in the year of 2009 was caused by the wrong identification of the diseases and the wrong pesticides applied, which didn't control the diseases, delayed the best control timing, increased the costs, and caused serious pollution to the soil, groundwater and surrounding environment. If the farmers had understood the symptoms of this disease, they would have known that the disease was infected by aleyrodid, and the focus should be put on the prevention rather than the control of the disease. Even for a type of new disease, we can slow down its expansion, and make some time for taking measures to reduce the costs and pollution. While some farmers do the oppositely, they do not take any measures until the pests and diseases start to spread, and the great losses cannot be saved even with great input.

(2) The pesticides used are too concentrated on several types, whose application doses and frequency maintain at a high level, and the farmers usually apply the pesticides with their bare hands. Once they find the good effects of one pesticide, they will stick to it, which, as a result, leads to the strong pesticide-resistance of the pests and pesticides in a long time. Some farmers even think that the higher the dose, and the more frequency the application, the better. According to an investigation, the vegetables in the protected areas of Shandong Province are applied with pesticides basically every seven to ten days during their whole growth process, which increases the residue of vegetables. Most farmers apply the pesticides with bare hands without any protection, and the sprayers are still traditional manual knapsack types, which have a serious problem of pesticide leakage, resulting in a great waste of pesticides and serious pollution of soils.

(3) A great variety of pesticide types results in the serious conformity of drug uses. There are nowadays many types of pesticides on market, some pesticides have been stored for a long time, and their labels have been removed. Those pesticides are applied by some farmers blindly, which, as a result, will causes great harms and even zero production. Some farmers compound the pesticides freely, which reduces the medical effect even to none; some farmers mistake high efficient with high toxic, they think that high efficiency can only be achieved by high toxic pesticides, and apply the highly-toxic pesticides to the vegetables.

(4) Both the market and sales of pesticides are substandard. With the increasing types of pesticides, some counterfeits appear, which not only discourages the farmer's enthusiasm, but also affects the reputation of pharmaceutical enterprises and the promotion of good pesticides. According to the investigation, many farmers acknowledge many efficient but low-toxic pesticides, but do not purchase them, because those pesticides are often mixed with some counterfeits; some pesticide dealers even compound the pesticides randomly and create a new brand, which not only harms the benefits of farmers, but also greatly pollutes the greenhouse environment.

3 Suggestions on the pesticide use for vegetables in protected areas of Shandong Province

According to the pesticide uses for vegetables in the protected areas of Shandong Province, some suggestions are proposed from four aspects.

3.1 The development and production of new pesticides must be guaranteed Relevant departments should strengthen the development and production of new pesticides. To improve the application environment of pesticides, reduce their toxicity and harms, and diminish their residual, we should reduce the pollution of pesticides to local soils and groundwater from their sources, especially the development of biological pesticides. For example, in order to promote the registration and development of biological pesticides, American EPA adopts a series of measures, such as establishing professional institutions, derating the materials for registration, and cutting down the approval time of registration, *etc.*, and more than thirty varieties of biological pesticides were registered during 2009 to 2011. Till now, about 151 varieties of effective pesticide components have been registered in China, and there are about 698 products, accounting for about 9% of the total registered pesticide products. The registered pesticides have been applied to 26 666 700 – 3 3333 300 hm^2 area, accounting for about 10% of total application area. Among the 151 varieties, there are about 48 varieties of botanical pesticides with more than 120 products and nearly 6 000 t annual production; thirteen varieties of bacteria mi-

croorganism pesticides with nearly 20 000 t annual production; twelve varieties of virus microorganism pesticides with nearly 4 000 t annual production; and eight varieties of fungal microorganism pesticides with nearly 1 000 t annual production, indicating that the biological pesticide industry in China has a broad prospect. The study of pesticide application technique has been included in National Science and Technology Support Program. With rice, vegetables, cotton and other crops as the research subjects, the multi-target coordinated application technique and high-efficient application technique of pesticides have been studied, new application techniques and supportive application devices have been developed[5]. As is seen from above, the government pays great attention to the development of pesticides.

3.2 The plant protection departments should actively carry out an investigation of pests and diseases and provide trainings for pesticide use The plant protection department should actively investigate local pests and diseases, and grasp their general development trend, carry out the experiments of new pesticides and promote the selection of biological and green pesticides. Regular training courses and lectures must be organized to introduce the farmers to how to recognize different types of pests and diseases, how to purchase high-quality pesticides, and how to scientifically apply the pesticides. According to the investigation, 90% farmers in Shouguang, Shandong Province get the information from both the pesticide dealers and such media channels as radio and TV, while the rest buy the pesticides recommended by others, indicating that the farmers are having their awareness in purchasing the pesticides. During recent years, some dealers start to learn about the vegetable pests and diseases in local areas and provide irregular training to local farmers, which help the farmers a lot, but the only 30% dealers can do that. The farmers welcome agro-technicians to carry out some training courses. Most pests and diseases occur nearly every year, to publish some brochures about how to prevent and control common pests and diseases will benefits a lot of farmers[19-20].

3.3 The farmers should keep learning and improving their quality The farmers are the direct users of pesticide. Based on the characteristics of farmers in Shandong Province, for example, the pesticide is generally purchased and applied by male farmers, who apply the pesticide by bare hands without any protection, and cannot control the standard application amount of pesticide. Their application technique should be improved. Although the farmers know that it is inappropriate to apply the pesticide when there are dews and in rainy days, their application dose and times still maintain at a high level, which, as a result, leads to a great waste of pesticide and serious pollution to local area. Thus, the farmers should be encouraged to take part in the training courses organized by local plant protection departments or pesticide production department, to learn the knowledge about pests and diseases, understand their occurrence laws and catch the weak link. Moreover, the pesticide application technique must be regulated, and the farmers should have a general knowledge about the harms of highly toxic and high-residue pesticides and the advantages of some efficient, low-toxic, low-residue and safe pesticides, so as to receive the best protective effects. Finally, the selection of pesticides must be based on their control subjects, growth period and application techniques, for example, difenoconazole is better to control powdery mildew, while propamocarb and dimethomorph are the best for controlling downy mildew[21]. The farmers must learn how to mix and alternate the use of pesticides, prevent the great concentration and dose of pesticide, and avoid the pesticide application in hot and rainy days, so as to control the harmful pests below the allowed level of economic losses.

3.4 The pesticide market should be supervised by the government The government should strengthen the supervision of pesticide market in accordance with the relevant laws and regulations. Producing and marketing counterfeit and highly toxic pesticide, as well as the dealers of counterfeit pesticide must be severely punished, and the order of pesticide order must be regulated so as to guarantee the pesticide quality and support agricultural production.

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(To page 123)

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(From page 120)

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