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ENVIRONMENTAL COST ANALYSIS OF CHEMICAL PREVENTION AND CONTROL TECHNOLOGIES OF CROP DISEASES AND PESTS

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Abstract: This article analyzes the causes and categories of environmental costs of chemical prevention and control technologies for crop pests and diseases, and points out that soil pollution, water pollution, fishery losses, pest resistance, natural enemy populations and biodiversity losses, bee product losses, and bee pollination losses are the main environmental Cost category. A preliminary analysis was made of the economic impact of each category of environmental costs, and it was initially calculated that the environmental costs incurred by my country's use of pesticides to prevent and control crop diseases and insect pests are at least 39.4 to 118.7 yuan/kg.
Keywords: Crop diseases and insect pests; Prevention and control technologies; Environmental costs; Biodiversity; Pesticide pollution

1 CAUSES AND CATEGORIES OF ENVIRONMENTAL COSTS

The cost of using chemical pest and disease prevention and control technologies includes huge environmental costs. For example, the extensive use of chemical pesticides has caused some prominent ecological and environmental problems such as the destruction of the natural ecology of farmland, the reduction of natural enemy populations and biodiversity, and the pollution of water sources and soil. These problems are all concentrated expressions of environmental costs [1-2]. The environmental costs generated by the use of chemical pest and disease prevention and control technologies usually lag behind economic activities in time and have no specific boundaries in space. They can harm the interests of individuals or groups that are not directly related to the economic activities, making it difficult to pursue liability and It is difficult to define and reflected in the market price of agricultural products, and cannot affect market supply and demand. This phenomenon is usually called "market failure" in economics [2].

Analyzing and evaluating the environmental costs of chemical prevention and control technologies has very important theoretical and practical significance, and is one of the important contents of ecological compensation evaluation [2-4]. Environmentally friendly green prevention and control technologies often face difficulties in promotion. Among them, the important reason is the lack of evaluation method system for the environmental cost of chemical prevention and control technology, especially the lack of quantitative evaluation method [2, 5]. If agricultural producers are not allowed to reap the benefits of reduced environmental costs, it will be impossible for agricultural producers to consciously adopt green prevention and control technologies. Therefore, scientific and reasonable analysis and evaluation of the environmental costs of various chemical prevention and control technologies can provide a basis for formulating agricultural technology promotion or agricultural ecological compensation policies, and are of great significance for promoting green prevention and control of crop diseases and insect pests and green agricultural development [5-8].

Pesticides are widely used in the practice of modern chemical prevention and control of pests and diseases in my country. Although the effective utilization rate of pesticides continues to increase with the improvement of pesticide application equipment, the effective utilization rate of pesticides is still only 38.8% in 2018 [6], with 40%~ 60% of pesticides are released into the environment, contaminating water sources and soil. Pesticide pollution of water sources first affects farmland aquatic biodiversity and causes fishery losses, and secondly pollutes irrigation and drinking water. Pesticides contaminate soil, changing the structure and physical and chemical properties of the soil, causing nutrient loss, resulting in crop yield reduction, excessive pesticide residues or heavy metals., resulting in crop yield reduction or loss [4,9-10]. These losses are the main environmental cost categories of modern pest control technologies.

The direct impact of the use of chemical pest and disease prevention and control technologies on the ecological environment has led to the decline of ecosystem service functions. The main impact categories can be summarized as ① reducing the population of natural enemies of pests or reducing biodiversity, and reducing the natural pest control function of the ecosystem., leading to an increase in the area or severity of pests and diseases; ② causing a reduction in the population of pollinating insects or a decrease in pollination capacity, resulting in reduced crop yields or bee product production due to insufficient pollination; ③ causing an increase in the resistance of pests and diseases to pesticides, leading to an increase in prevention and control costs.

The environmental costs incurred by the use of chemical pest and disease prevention and control technologies are mainly borne by agricultural product producers or the public. The environmental costs generated by the use of chemical prevention and control technologies are often intertwined with social costs. For example, the use of pesticides causes

environmental pollution, and the pollution to the environment is a direct environmental cost. The investment costs for repairing the environment or preventing environmental pollution can also be classified as social costs. The cost [1, 3-4] is generally borne by the finance (taxpayers) in our country today.

2 PRELIMINARY CALCULATION OF ENVIRONMENTAL COSTS

2.1 Soil Pollution

Over the past 50 years, chemical prevention and control of crop diseases and insect pests in my country has The large-scale use of technology has resulted in pesticide residues in soil. In recent years, the detection rate of typical organochlorine pesticides such as DDT and 666 in soil in my country is still very high [10]. Different types of soil in Northeast my country The concentration of organochlorine pesticide residues in soil, dry fields and vegetable fields is relatively high [11]. In North my country, taking Shandong Province as an example, 15 kinds of organochlorines Pesticides all have a high detection rate, and the detection rate of isomers of BHC, DDT, aldrin, dieldrin, endrin and endosulfan is 100%. The soil in various regions of the Shandong Peninsula The order of organochlorine residues is: orchard > mining field > corn field > wheat field > cotton field [12]. According to statistics, by 2017, at least 5% of the cultivated land in Northeast China, at least 10% of the cultivated land in the Yangtze River Delta and Southwest China, 17% to 30% of the cultivated land in East China, and 10% to 30% of the farmland in South China were contaminated by pesticides and heavy metals [10-12]. For example, 1.333 million to 2 million hm2 per year The agricultural output value potential of contaminated cultivated land is reduced by 3% to 5%, and it is estimated that the environmental cost of soil pollution is 5.5 billion to 9 billion yuan/year.

2.2 Water pollution, Fishery Losses

Water-soluble pesticides are widely used in farmland, especially rice fields, in my country, and 50% of the water-soluble pesticides can be lost to water bodies and lost to aquaculture water bodies with surface or underground runoff [9]. According to statistics, fishery losses due to pesticide contamination from 2006 to 2011 were 55% billion [9], it is estimated that the fishery losses caused by pesticides contaminating water sources are 900 million to 1 billion yuan per year.

2.3 Pest and Disease Resistance

The long-term excessive use of chemical pesticides in some major crop-producing areas in my country has led to the development of resistance to some major crop diseases and insect pests. In the 25 years from 1990 to 2015, more than 80 major pests and diseases have become resistant to pesticides. Among them, pests and mites exceed 37 species, 21 species of plant pathogenic bacteria and 25 species of weeds [13]. The development of pest resistance has led to the loss of pesticide control effects. Some resistant pests and diseases have broken out on some major crops, causing a series of major losses to agricultural production and significant environmental costs. 2018 The results of national agricultural pest resistance monitoring in 2014 showed [14] that all populations of brown planthoppers were highly resistant to the first-generation neonicotinoid agent imidacloprid (resistance multiple >1000 times), and were resistant to the insect growth regulator agent thiacloprid. The cotton bollworm population in the North China cotton area is at a medium to high level of resistance to the pyrethroid cyhalothrin (the resistance multiple is 58 to 192 times); all cotton aphids have The population is at a high level of resistance to the pyrethroids cypermethrin, deltamethrin, and the neonicotinoid imidacloprid (the resistance multiples are greater than 40,000 times, greater than 4,500 times, and greater than 200 times, respectively). times); diamondback moth populations in the Yangtze River Delta vegetable producing areas are moderately to high-level resistant to indoxacarb (resistance times 71 to 239 times). Due to the lack of statistical data to support the scope and extent of occurrence of antibiotic-resistant pests and diseases, it is difficult to estimate the specific amount of such environmental costs.

2.4 Natural Enemy Populations and Biodiversity Loss

In China's modern chemical prevention and control technology, the extensive use of chemical pesticides has killed natural enemy populations, destroyed biodiversity, and weakened the damage control effect of natural ecology [15-16]. There are more than 1 million species of insects alone on the earth, and there are more than 1,600 species of pests and diseases that damage crops in my country [6]. Survey results of Japan's apple orchards in the northeastern region show that the long-term use of chemical pesticides has rapidly reduced the number of insect species, from more than 130 to 180 species to just a few. At the same time, more than 40 natural enemies of pests have disappeared; survey results of paddy fields show that, the number of paddy field pests has decreased from the original 210 species to more than 10 species [15]. The long-term use of chemical pesticides has an irreversible impact on biodiversity, and can cause irreversible changes in insect populations, plant communities, soil animals and microbial flora [15-16]. The remarkable feature is that it causes damage to the original ecosystem. The suppressed secondary population becomes the new

primary harmful population. The economic characteristics are the increase in the area where pests and diseases occur and the area under control, which leads to a rapid increase in the cost of pest control. From this, we can infer the environmental costs caused by the reduction of natural enemy populations and biodiversity caused by the use of modern prevention and control technologies in China.

According to national plant protection professional statistical data [17], before the 1970s, the area where crop diseases, pests, weeds, and rodents occurred nationwide was less than 100 million hectares. By the early 1990s, it had doubled to 330 million hectares. hm2 times; by the beginning of the 21st century, it has climbed to more than 400 million hm2 times. on; continued to climb to 510 million hm2 in 2012 the highest position of the times, thereafter By 2017, it will decrease slightly to 440 million hm2 year by year. About times. The seriousness of pests, diseases, weeds and rodent infestations in the 50 years from 1968 to 2017 The degree has increased by 4 times, resulting in the prevention and control area also increasing by 4 to 5 times.

Based on this calculation, in the past 50 years, the use of chemical prevention and control technology has caused the reduction of natural enemy populations and biodiversity, and the prevention and control area has averaged 9.9333 million hm2 per year. If the current approximate average control cost of various crops (including pesticide costs and pesticide application labor costs) is 15 to 25 yuan/666.7m2 Calculated once, this type of environmental cost ranges from 2.2 billion to 3.7 billion yuan per year.

2.5 Bee Pollination and Loss of Bee Products

The actual loss of bee populations caused by my country's chemical prevention and control technology is determined by the toxicity of the pesticide and the exposure to the pesticide, and is also related to the dosage form and application method of the pesticide [18-21]. According to statistics from the Food and Agriculture Organization (FAO), 71 of the more than 100 crops that provide 90% of the food in 146 countries are pollinated by insects such as bees [18-19]. Bee pollination of crops worldwide is worth nearly $200 billion each year. There are more than 8 million bees kept in our country, and the output value of bee products is about 30 billion yuan. According to statistical data from 2006 to 2008, the total value contributed by bee pollination to the production of 36 economic crops in my country reached 304.22 billion yuan/year [18-19]. Since the use of pesticides reduces the bee population by 1% to 3% [20-21], it is estimated that the impact of chemical prevention and control technology on bee populations causes a loss of bee product output value of 300 million to 900 million yuan per year., pollination losses range from 3 billion to 9.1 billion yuan/year.

Based on the comprehensive analysis of the above environmental costs, preliminary estimates indicate that the annual environmental costs incurred by the use of chemical prevention and control technologies in my country are at least 12.2 billion to 236.8 billion yuan (Table 1). Based on the average annual pesticide consumption of 310,000 tons (100%) in my country in the past 10 years, the environmental cost of using pesticides to prevent and control crop diseases and insect pests in my country is at least 39.4 to 118.7 yuan/kg. Compared with foreign countries, Pimental et al. (2005) estimated that the environmental and social costs incurred by the use of chemical pesticides in the United States are at least US$12 billion per year [22]. Pretty and Bharucha (2015) reported that the environmental and social costs of using 1 kilogram of pesticides ranged from US$4 to US$19 [23].

Table 1 Preliminary calculation of environmental costs of chemical prevention and control technologies

Environmental cost category	Amount (100 million yuan/year)	Calculation basis
Soil pollution	55~90	Published literature
Water pollution, fishery losses	9~10	Published literature
Pest and disease resistance	big	Lack of statistical basis for calculation
Natural enemy populations and biodiversity loss	22~37	National plant protection professional statistics
bee product loss	3~9	Published literature
Loss of pollination by bees and others	33~100	Published literature
total	122~368	

3 DISCUSS

The environmental costs of chemical control technologies are obviously closely related to plant protection policies. The Ministry of Agriculture proposed the concept of “public plant protection, green plant protection” in 2006 and began to promote green prevention and control technologies [5, 24]. With the large-scale promotion and application of green prevention and control technology, 2008-In 2012, the increase in the occurrence and control area of crop diseases and insect pests nationwide decreased year by year, indicating that the environmental cost of chemical prevention and control technology has been declining year by year in the past 10 years. From 2013 to 2017, the national crop disease

and insect pest occurrence and control area experienced negative growth for five consecutive years [17], indicating that the farmland ecological environment has been significantly improved in the past five years, and the ability of natural pest control has been significantly enhanced. The implementation of scientific plant protection policies and plant protection concepts has significantly reduced the environmental costs of modern chemical prevention and control technologies.

The environmental cost of chemical prevention and control technologies for crop pests and diseases is closely related to the type and amount of pesticides used. In the 1960s, my country began to use organochlorine and other chemical pesticides in large quantities. By the 1990s, the extensive use of organochlorine pesticides had caused serious pollution to my country's agricultural ecological environment, especially the soil ecological environment, and brought huge environmental costs. More than 30 years have passed since the ban on the use of organochlorine pesticides began in the 1990s, but organochlorine pesticide residues are still widely found in soil testing. In 2007, the Ministry of Agriculture issued an announcement prohibiting the use of five highly toxic pesticides including monocrotophos. So far, more than 20 highly toxic pesticides have been banned and more than 30 pesticides have been restricted. Highly toxic The proportion of pesticides has been reduced from about 30% in the past to less than 2% [6]. In the process of pest control in the past 50 years, as the amount of pesticides increases and decreases, the environmental costs of modern chemical prevention and control technologies also increase and decrease, which is reflected in the increase and decrease in the occurrence and control area of pests and diseases [17]. From a macro level, the use methods and scientific level of pesticides in modern prevention and control technologies are the determining factors of environmental costs. The most effective way to reduce the environmental costs of modern prevention and control technologies is to achieve pesticide reduction and harm control.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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