Design of Agricultural Cleaner Production Technology System

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Abstract Based on the introduction of agricultural cleaner production, technology system design of planting cleaner production is discussed from five aspects of water-saving irrigation technology, fertilization technology, diseases and insects control technology, straw comprehensive utilization technology and plastic film pollution control technology. Cleaner production technology system of livestock and poultry raise is constructed from the aspects of source control technology, reduction technique in breeding process and end control technology. Thus, the implementation of agricultural cleaner production technology system has profound impact on the agricultural sustainable development in China.

Key words Non-point source pollution; Agricultural cleaner production; Technology system; China

1 Connotation of agricultural cleaner production

Agricultural cleaner production technology system is one of the agricultural technologies which is urgently needed in China. It plays an important role in preventing agricultural environmental pollution and exploring circulation of agricultural resources. During the long-term production, people use a great amount of pesticides, fertilizer, plastic film and other agro-chemicals in order to pursue the improvement of crop yield per unit area, which results in the degradation of agricultural natural resources and the pollution of agricultural environment. At the same time, residues of veterinary drugs and feed additives, as well as solid waste such as straw and livestock manure, are also the major reason of the deterioration of agricultural ecological environment. Therefore, with the increase of arduousness and urgency in non-point source pollution control, vigorously developing the agricultural cleaner production technology system, with water saving irrigation, agricultural solid waste utilization, and environment-friendly fertilizer, pesticide and agricultural film as the main bodies, is bound to have a profound impact on agricultural sustainable development in China.

Cleaner production starts from the industrial field. In-depth study has accumulated a great amount of experiences and formed relatively mature technical ideas and complete system of laws and regulations. Compared with the industrial field, agricultural cleaner production has not yet fully carried out, at the starting period of theoretical explorations and experience accumulation. But their basic contents are all the same, that is, reducing the production of pollutants by preventing the pollution in production, products and service. Its essence is to promote source reduction and process control. Reduction of resource and energy consumption, as well as decrease of pollution production and ecological damage is a kind of transformation from passive reaction to active action of environmental protection strategy.

The *Cleaner Production Promotion Law of the People's Republic of China* points out that agricultural producers should use chemical fertilizers, pesticides, agricultural films and feed additive scientifically to improve the cultivation and breeding techniques, and to realize the high quality of agricultural products, the resource utilization of agricultural waste, and the control of agricultural pollution. And it is forbidden to use toxic and hazardous waste as a fertilizer or for land reclamation. Therefore, it can be concluded that agricultural cleaner production includes mainly the planting and breeding industries in agricultural production. Result of agricultural cleaner production is " realizing the high quality of agricultural products, the resource utilization of agricultural waste, and the control of agricultural pollution" by " using chemical fertilizers, pesticides, agricultural films and feed additive scientifically, and by improving breeding and planting techniques".

2 Technical system design of cleaner production of planting industry

2.1 Water-saving irrigation technology Water-saving irrigation is to use various measures of engineering water-saving techniques, agricultural water-saving technical measures, and administrative water-saving measures to reduce the irrigation water from surface water (rivers, reservoirs and so on), groundwater or other water sources, in order to achieve the purpose of saving water resources. Irrigation water is the water consumption from water source and field to crop absorption, mainly including water resource allocation, water delivery and distribution, field irrigation and crop absorption. Corresponding water-saving measures are adopted to form a complete system of water-saving irrigation technology.

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2.1.1 Water-saving and anti-seepage project of canal. One of the keys of irrigation is water delivery, which can not be separated from canal. Earth canal without anti-seepage has strong filtration. Water canal without anti-seepage has only 50% utilization rate of canal water. Anti-seepage acceleration, farm canal network, and water leakage control are the keys to improve the utilization ratio of water. Compared with the canal without seepage control, canal with seepage control can reduce the seepage loss by 60 –90%, accelerate the speed of water delivery, and improve the efficiency[1].

2.1.2 Adopting advanced field irrigation technology. At present, field irrigation commonly use flood irrigation and ditch irrigation with great water demand in agricultural irrigation. Adopting advanced technology is the development direction of field irrigation, as well as an important part of water-saving irrigation. Sprinkler irrigation is a kind of mechanized and efficient water-saving irrigation technology, having the advantages of saving water, land and labor force, increasing yield and strong adaptability to soil and terrain. Compared with surface irrigation, field crop irrigation can save water by 30% –50% and increase yield by 10% –30%[2]. Micro jet and drip irrigation are water-saving irrigation technologies, which are fine, modern and efficient. They can apply fertilizer and pesticide while irrigation, with above 90% irrigation efficiency.

2.1.3 Improving surface irrigation technology. Before the flood irrigation and ditch irrigation are completely replaced by advanced technology, improving surface irrigation technique is still an important measure for water-saving irrigation. Surface water-saving irrigation technology in field is to change big border into small one, to transform long ditch into short one. Based on land leveling, border and ditch become more rational in size, which can reduce irrigation quota by 20 –25%. At the same time, laser is used to control the leveling technique, to improve the ditch irrigation technology, the brake pipe irrigation technology, the surge flow irrigation technology and other surface irrigation technologies, so as to form field engineering design and application mode suitable for different types of irrigation areas, so as to achieve good water-saving yield-increasing effect[3].

2.1.4 Adopting agronomic and biological water-saving techniques. Water-saving agriculture is a huge system engineering closely combining agriculture and water technologies, with comprehensive development of water, soil and crop. Through improving farming and cultivation measures, no additional investment is needed to significantly improve the water use efficiency in agricultural field under the continuous improvement of water-saving irrigation. Agronomic water saving mainly includes water-suiting plant, selection of drought-resistant varieties, moisture conservation cultivation techniques, moisture conservation coverage techniques, water-fertilizer coupling techniques, soil water-holding agent, crop transpiration control technology and other agronomic water-saving techniques.

2.2 Fertilization technique Agricultural sustainable development is aim to obtain high crop yield, high fertilizer efficiency, high product quality, soil fertility maintaining or improving, environmental protection and so on. To achieve these goals, chemical fertilizer is applied timely and appropriately in proportion, and is in accordance with the needs of soil nutrients and crop growth, accompanied by the application of organic manure and implementation of farmland fertilization technology[4-6].

2.2.1 Formula fertilization technique. Crop formula fertilization is also known as soil testing fertilization, which recommends fertilization based on nutrient determination of soil and plant, that is, making technical scheme of formula fertilization according to soil nutrient content, crop varieties, production level, fertilizer varieties and other factors. Formula fertilization is a highly efficient and sustainable fertilization, which should combine organic fertilizer and inorganic fertilizer together, major element and micro and medium elements together, and base fertilizer and top dressing together, scientifically adjust the proportion of organic fertilizer and the time of top dressing, reduce the loss of nitrogen, improve the use efficiency of fertilizer, achieve the high yield and quality of crop, and maintain the soil fertility.

2.2.2 Increasing the use of organic fertilizer. Organic fertilizer is a fertilizer having organic content and offering comprehensive nutrient for crops. Application of organic fertilizer can increase the water retention, fertilizer conservation, and air permeability of soil, update the soil organic matter, and maintain and enhance soil fertility. At the same time, it can enhance the quality of agricultural products and improve the market competitiveness of agricultural products. Therefore, we should organize the technicians in township agricultural departments in order to offer technical guidance, improve the quality and quantity of organic fertilizer application, make great efforts to return the straw into field, closely cooperate with the farm machinery, livestock and other departments, and improve the returning rate of straw. At the same time, we should take encourage measures, mobilize the enthusiasm of the peasants, use all sources of organic resources, and carry out straw returning and composting fermentation of organic fertilizer.

2.2.3 Improving soil fertility of farmlands. Improving soil fertility of farmlands is the main way to enrich farmland. Its central task is to carry out comprehensive adjustment on plant material basis, plant nutrition and soil ecological conditions through multiple ways, and to establish technical system of farmland fertility suitable for cropping system. To be specific, intercropping and rotation of crops and leguminous crops are used to reduce the use amount of fertilizer and the burden on peasants, to improve the soil fertility of farmland, and to control the pests and diseases.

3 Control techniques of disease pest and weed

Pesticide is an important agricultural means of production for disease and pest control in modern agricultural production, which is irreplaceable. However, pesticide is also a chemical having toxic attribute, as well as a major pollutant discharged by agriculture. Simply using a large number of chemical pesticides to control pests for a long time will lead to resistance of

pests to common chemicals. Besides, it will also result in the rampant pest and increased secondary pests due to mass destruction of natural enemies. Therefore, insect and pest control can not simply rely on pesticides. We should use a variety of integrated control technologies of insect pest to control and reduce the damage. Control methods of insect pest can be summarized as agriculture, biology, chemistry, physics, and integrated pest control[7-8].

3.1 Agricultural control methods Agricultural control is a basis for comprehensive prevention and control, playing an important role in controlling disease pest and weed. Agricultural control based on the occurrence and damage of disease pest and weed not only has certain relation with disease pest and weed, but also is related to the farmland environmental conditions, crop tolerance or resistance, and agricultural cultivation measures. Major measures for the control of disease pest and weed are using rotation, selecting disease-resistant and insect-resistant crop varieties, adopting rational fertilization and water usage, strengthening field management and so on.

3.2 Biological control methods Biological control includes using natural enemies to control disease pest and weed and using biological pesticides. Using natural enemies to control disease pest and weed has the advantages of no pollution, ensuring the safety of human and animal, and reducing the usage of chemical pesticides. Chemical pesticide includes biochemical pesticide and microbial pesticide, such as sex attractant for insects, alarm pheromone, pheromone having aggregation effect, and nonaggression pheromone.

3.3 Chemical control methods Chemical control method is an important component of comprehensive control. In general, it is successful to use chemical pesticides as the main means of chemical control. When disease pest and weed has reached or exceeded the economic threshold, chemical control is the best emergency measure. Reasonable application of pesticides can reduce, or even avoid, the damage. Its technical point is that strictly use drugs according to the economic threshold, strictly select the most appropriate pesticide according to the control object, replace pesticides on time, grasp the appropriate concentration and dosage, master the timing of medication, select the most appropriate formulations and spraying methods, and use the right medication position.

3.4 Physical control methods Physical control methods for disease pest and weed in agricultural production are artificial hunting, syrup trap, light trap, manual and mechanical weeding, artificial removal of diseased leaves and plants, heat-treated seed sterilization, high-temperature sterilization in stuffy studio.

3.5 Comprehensive control technology of harmful organisms Comprehensive control technology of harmful organisms is to use various comprehensive technologies to control the pests having potential hazard to agricultural crops. Natural control force should be made full use of by the greatest extent, as well as the integrated approach that can control the population quantity. The final goal for comprehensive control of harmful organisms is to maintain the population density of harmful organism under the level of economic injury, but not to wipe out the harmful organism that damages the crops. Firstly, it is chiefly manifested in the fair enough economy. Drug use of economic threshold value is used when harmful organism rises to a certain density. Thus, the optimum input-output ratio can be obtained without causing waste due to the low density of harmful population, or causing loss of crop yield due to the high density of harmful population. Secondly, it is manifested in the relatively reasonable ecology, that is, the rest of pest population can feed its natural enemies, can maintain the organization and structure of farmland ecosystem, and reduce the proliferation of drug-resistant population. Thirdly, it is manifested in the relatively safe social environment, that is, avoid too much environmental pollution and pesticide residue due to the excessive use of chemical pesticides.

4 Comprehensive utilization technology of straw

4.1 Straw-returning technology Straw-returning to field can be carried out through direct returning, pile fermentation and so on. Direct returning is to crush straw by using combine harvesters when harvesting. Then, throw the straw on the ground surface and directly plow under to enrich soil. However, straw directly returning to field can not kill the egg or harmful micro-organisms. Therefore, sterilization measures are needed before plow[9]. Pile fermentation is to apply straw into soil after fully decomposition under high temperature. Earthworm can be stocked during pile composting, combining the functions of ripping, crushing and ventilation together, so as to improve efficiency of composting[10]. Meanwhile, earthworm can be also used as high-protein feedstuff. Besides, commercialization of compost can be realized by using poultry manure and straw to produce organic fertilizer granules[11]. And manure returning is to use straw as feedstuff; and then turns the straw into manure and applies it into the soil. This method is the most scientific and has ecological nature.

4.2 Conversion technology of straw into feedstuff Conversion of straw into feedstuff is the pre-renewal project of manure returning of straw, that is, improving the quality and utilization of straw fodder through processing. Simple conversion of straw into feedstuff is to use crop straw processing equipment to compress the corn stalks, wheat stalks, and low-value fodders after adding the transforming agent. Ammonification alkalization and curing of straw can be achieved, as well as the complete degeneration of straw lignin by the temperature and pressure generated by compression. Finally, they can be made into the basis of food for ruminants.

4.3 Conversion technology of straw into fuel As a fuel, straw has a very broad prospect, with the calorific value of about 18 –21 MJ/kg (calorific value of raw coal is 20.9 MJ/kg). However, the packing density of straw reaches 50 – 120 kg/m^3, which is relatively disperse and large in volume[12]. Therefore, pretreatment is needed when collecting the straw, including bundling, drying, grinding and compression. Combining with straw solidification and the blended fuel technology with coal,

straw power plant or thermoelectric production can be established, which not only saves energy and reduces the SO_2 emissions, but also increases the income of farmers. Jinzhou City Straw Plant is the first power plant in China that completely uses straw burning to generate power. It generate 1.2×10^8 kw·h power each year, and burns 2×10^5 tons straw. Compared with coal-fired power plant in the same scale, it saves 10^5 tons of coal each year, reduces more than 6×10^5 tons of sulfur dioxide emissions, and decreases 400 tons of dust emissions[13].

4.4 Raw material of industrial production As the raw material of industrial production, biogas from biotransformation of straw can be used as the raw materials of industrial production. After burning into ash, straw can be used to produce activated carbon and sodium silicate. Besides, straw can be directly used to produce the light insulation brick or the light building plate[14].

4.5 Control technology of film pollution Control of plastic film is mainly the development and application of degradable plastics from the aspects of production, management, Utilization, removal, recovery and reuse.

4.5.1 Development and application of degradable plastics. There are three types of biodegradable plastics, which are photodegradable plastics, biodegradable plastics and photo-biodegradable plastics. However, due to the high price of degradable plastics and the poor control of degradation, it is difficult to be used widely. At the same time, research on the effects of plastic grains on farmland after degradation is still not deep enough, and a lot of resources are wasted after degradation. Thus, a better degradable plastic needs to be further studied and explored.

4.5.2 Recovery of agricultural plastic film. At present, mulching film in China has the problems of few varieties, poor function, inadequate thickness, poor uniformity and disjunction of production and application, which results in the easy damage and difficult recovery of mulching film. Therefore, government should vigorously promote the use of anti-aging mulching film above 0.014 millimeter, which is easy to be removed and recovered. At the same time, production of waste film can be improved and residual control can be achieved by grasping the time and technology of uncovering plastic film, and by screening the best uncovering time. For instance, film-covered cotton is first disclosed at budding period or from late June to early July. Reduction of mulching time and tenacious film can help to remove the film with the recovery rate being 95%[15].

4.5.3 Strengthening the research on recycling machinery of plastic film. It is clearly unrealistic to recycle the plastic film manually and mechanical recycling is necessary. The fundamental way to recycle plastic film is to increase the development and research on plastic film recycling machinery. At present, there are two aspects of the plastic film recycling. One is recycling of new plastic film; the other is the recycling of residual plastic film in history. As for the recycling of new plastic film, as long as government and farmers pay attention to it, the problem would be solved. As for the recycling of residual plastic film in history, there is also a technical problem except the problem of understanding. Research and use of plastic film machinery is an important means. Plastic film recycling machinery at present mainly uses the tooth harrow, harrow and tooth roller for recycling. Normally it is combined with the plow, straw chopping and mechanical traction, with the recovery rate of 70 –80%.

5 Clean production technology system for livestock and poultry breeding

The key for clean production of livestock and poultry breeding is the utilization and disposal of livestock and poultry manure. Reduction of waste emissions can reduce the cost of pollution control, maximize the effectiveness of pollution control, and reduce the difficulty degree of use in order to create conditions for improvement of control effect and the implementation of the resource utilization. Disposal of quantitative reduction is an extreme important prerequisite for pollution and control of livestock and poultry manure. Before the use and control of pollutants, pollutant emission should be reduced by taking various measures. Technically, quantitative reduction must reduce emissions from the whole process of livestock and poultry breeding[16-17].

5.1 Source control technology Considering from the source of breeding, on the one hand, breeding structure of rational planning and intensive farming have adopted the combination mode of farming and animal husbandry, in order to achieve the collection, processing, consumption and control of aquaculture pollutants. According to the actual situation, we should also restrict the breeding quantity, reduce the soil load of pollutants, cut down the water and soil pollution caused by nutrients (nitrogen, phosphorus), toxic residues and pathogens. On the other hand, we should also research, develop, introduce and promote the high-quality varieties, as well as scientific breeding and proportioning ratio, apply high-efficient growth-promoting additive, and improve the feed quality and physical form by high and new technology.

5.2 Reduction techniques of breeding process Considering from the breeding process, on the one hand, environmental protection feed and environmental feed additive can be adopted according to the specifications of green food, so as to adjust the nutrition of pig, enhance the conversion ratio of feedstuff, and reduce the emissions of nitrogen and phosphorus waste. On the other hand, we should adopt the way of artificial dry manure, reduce the use of water, and save the project cost of water consumption and follow-up treatment facilities.

5.3 End control technology Considering from the culture end, during the treatment of culture pollutant, on the one hand, dry dung and dry residue can be fermented into high-quality organic fertilizer. Through rational planning, crop farming and livestock breeding industry can be combined together to intake the fermentation product of dung. On the other hand, high-efficient solid-liquid separation technology is adopted to achieve the quantitative reduction of pollutant treatment.

6 Conclusion

Agricultural clean production technology has played an important role in agro-ecological environmental degradation, agri-

cultural non-point source pollution, and pollution of livestock and poultry breeding industry. However, cleaner production in agricultural field has disadvantages in theoretical study and practical implementation. A unified understanding has not yet formed; and academia, government and farmers have not yet attracted great attention. Agricultural clean production has not been effectively applied and implemented in practice. Meanwhile, Cleaner production in China is just at the initial stage. With the continuous improvement of people's demands for life quality and the growing emphasis on environmental protection, clean production bears great market potential. Therefore, establishing a set of feasible policies, as well as doing a good job in propaganda and the active participation of government, farmers and enterprises, will promote the development of cleaner production in China[18].

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农业清洁生产技术体系设计

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摘要 在介绍农业清洁生产的内涵的基础上,从节水灌溉技术(渠道的工程防渗节水、采用先进的田间灌溉技术、改进地面灌溉技术、农艺及生物节水技术)、施肥技术(配方施肥技术、增施有机肥、农田培肥)、病虫草害防治技术(农业防治技术、生物防治方法、化学防治方法、物理防治方法、有害生物综合治理技术)、秸秆综合利用技术(秸秆还田技术、秸秆饲料化技术、秸秆燃料化技术、作为工业生产原料)、地膜污染控制技术(可降解塑料的开发应用、农用地膜的回收、加强地膜回收机械的研制)5 个方面探讨了种植业清洁生产的技术体系设计,从源头控制技术、养殖过程的削减技术、末端控制技术 3 方面构建了畜禽养殖清洁生产技术体系,以期通过农业清洁生产技术体系的实施对中国农业可持续发展产生深远的影响。

关键词 面源污染;农业清洁生产;技术体系