Post-print of the Official Launch of the Ministry of Science and Technology' s 13th Five-Year Plan Key R&D Special Project on Comprehensive Prevention, Control and Remediation Technologies for Agricultural Non-point Source and Heavy Metal Pollution in Farmland: Demonstration of Prevention and Cont···

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Abstract

The lower reaches of the Yangtze River are characterized by high agricultural intensification and frequent precipitation, with severe non-point source and heavy metal pollution posing a serious threat to grain production and human health. It is crucial to control and mitigate environmental pollution and decline in agricultural product quality in surrounding farmland caused by unreasonable use of agricultural inputs, small and micro enterprises, and Cd, Pb, and Cu from copper mines, maintain stable and high grain yields, improve and enhance living environmental quality, and achieve coordinated development of environment-resources-food-health. In response to this societal need, the Ministry of Science and Technology and the Ministry of Agriculture recently approved the first batch of key special projects for "Research and Development of Comprehensive Prevention and Control and Remediation Technologies for Agricultural Non-point Source and Heavy Metal Polluted Farmland," with a total of 11 special projects, including the "Demonstration of Prevention and Control Technologies for Agricultural Non-point Source and Heavy Metal Pollution in the Lower Reaches of the Yangtze River," to be officially launched in the near future.

Full Text

Project Launch: Integrated Prevention and Remediation Technologies for Agricultural Non-Point Source and Heavy Metal Pollution in Farmland

Background and Significance

The lower Yangtze River region faces severe non-point source and heavy metal pollution due to intensive agricultural practices and frequent precipitation, posing significant threats to food production and human health. Addressing environmental degradation and declining agricultural product quality caused by improper use of agricultural inputs, as well as Cd, Pb, and Cu contamination from small enterprises and copper mines, is critical for maintaining stable grain yields and improving environmental quality. In response to these challenges, the Ministry of Science and Technology and the Ministry of Agriculture recently approved the first batch of key special projects under the "13th Five-Year Plan" for integrated prevention and remediation of agricultural non-point source and heavy metal pollution in farmland, including 11 specialized projects that will launch imminently.

Project Overview

The project "Demonstration of Prevention and Control Technologies for Agricultural Non-Point Source and Heavy Metal Pollution in the Lower Yangtze River" (Project No.: 2016YFD0801100) is led by the Institute of Soil Science, Chinese Academy of Sciences. The research consortium comprises 13 partner institutions, including Zhejiang University, Jiangsu Academy of Agricultural Sciences, Shanghai Jiao Tong University, Nanjing Agricultural University, Jiangxi Academy of Agricultural Sciences, Nanjing Institute of Environmental Sciences of the Ministry of Environmental Protection, Anhui Agricultural University, Ningbo Academy of Agricultural Sciences, Amway (China) Plant R&D Center Co., Ltd., Jiangsu Runguo Agricultural Development Co., Ltd., Shanghai Zizaiyuan Agricultural Development Co., Ltd., and Suzhou Hemei Biotechnology Co., Ltd. This interdisciplinary team brings together experts in soil science, plant nutrition, environmental science, microbiology, botany, and food science.

Research Framework and Objectives

Targeting critical issues such as low nitrogen and phosphorus use efficiency, combined heavy metal pollution, limited prevention technologies, poor system integration, and low technology maturity in the lower Yangtze region, the project focuses on typical cropping systems in this area. Building upon fundamental research on nitrogen and phosphorus loss mechanisms, toxic chemical/biological contamination processes, and heavy metal pollution characteristics, the project will integrate comprehensive technologies and products for paddy field nitrogen and phosphorus loss prevention, aerobic fermentation technologies and intelli-

gent equipment for agricultural waste, blocking and passivation technologies and materials for heavy metal pollution, and geochemical engineering remediation techniques. These will be combined with multi-level nutrient cycling technologies, low-accumulation crop varieties for heavy metals, and oxygen-enhanced irrigation with heavy metal passivation techniques to construct integrated technical models for non-point source pollutant interception and reduction (nitrogen, phosphorus, and pesticides) and comprehensive heavy metal pollution prevention and remediation. The project will develop technical specifications, conduct engineering demonstrations for typical cropping systems, and achieve the scientific goals of "reducing input while increasing efficiency, preventing pollution, maintaining high and stable yields, and ensuring agricultural product safety."

Research Topics

Based on pollutant types and levels, combined with land use patterns and geographic conditions, the project is organized into six research topics: (1) Integration and demonstration of paddy field non-point source pollution prevention technologies in river network plain areas; (2) Integration and demonstration of dryland non-point source pollution prevention technologies in river network plain areas; (3) Integration and demonstration of non-point source pollution prevention technologies in hilly small watersheds; (4) Integration and demonstration of prevention technologies for lightly Cd- and Pb-polluted farmland; (5) Integration and demonstration of prevention technologies for moderately and heavily Cd- and Cu-polluted farmland; and (6) Integrated prevention and demonstration of combined non-point source and heavy metal pollution.

Research Components

The research comprises four main components: First, developing a series of region-specific key technologies at existing research bases, including nitrogen-efficient emission reduction technologies to control ammonia volatilization in paddy fields, oxygen-enhanced irrigation techniques, integrated mechanical ridge formation and side-strip fertilization, real-time precision fertilization based on digital camera spectral information, quantitative control planning for multi-source combined non-point source pollution in small watersheds, pollutant interception and reduction technologies, screening of low-accumulation crop varieties for cadmium and lead, large-scale seedling cultivation and safe overwintering techniques for hyperaccumulator plants (*Sedum plumbizincicola*), combined passivation technologies for heavy metal pollution, enhanced phytoextraction techniques using hyperaccumulators, integrated pollution control and efficiency improvement through ecological rice-fish farming, and biochar-based pollution control for combined organic-heavy metal contamination in vegetable fields.

Second, systematically integrating existing individual technologies with these regional innovations to form comprehensive technical systems, including year-round, full-process, three-dimensional prevention systems for paddy nitrogen

and phosphorus pollution; interception and reduction systems for dryland nitrogen, phosphorus, and pesticide pollutants; optimized technology combinations for different land use types in hilly watersheds; integrated prevention and remediation systems combining low-accumulation crops, passivation, and agronomic regulation for lightly polluted soils; integrated systems combining exclusion-passivation-safety-production-remediation for moderately and heavily polluted soils; and comprehensive prevention systems for dual non-point source and heavy metal pollution.

Third, constructing integrated technical models for the lower Yangtze region based on these systems, developing technical specifications, and conducting validation and monitoring assessments in core demonstration zones. Fourth, establishing large-scale integrated demonstration areas to showcase these technical models, conduct technology dissemination and training, and evaluate demonstration effectiveness through established pollution monitoring and assessment methods.

Key Innovations

The project' s main innovations include: (1) Shifting from "reduction-focused" to "efficiency-focused" strategies through integrated combinations of characteristic cropping systems, deep fertilizer placement, slow/controlled-release fertilizers, and nutrient recycling technologies to achieve reduced input, increased efficiency, non-point source pollution prevention, and high stable yields. (2) Addressing the new characteristics of combined non-point source and heavy metal pollution by developing key integrated prevention technologies centered on "ecological farming," "low-accumulation crops," and "novel passivating agents." (3) Creating a year-round, full-process, three-dimensional regional prevention system through comprehensive integration of "source reduction of nitrogen and phosphorus," "nutrient cycling," "ecological farming," "ammonia volatilization control,""microbial agents,""critical node control,"and "regional joint prevention," thereby strengthening system integration. (4) Optimizing and integrating technologies including "low-accumulation crops," "hyperaccumulator plants," "heavy metal passivation," "agronomic regulation," and "microbial enhancement" to enable remediation and safe utilization of farmland under alternating wet-dry conditions, different heavy metal types, and varying pollution levels.

Expected Outcomes

Upon completion, the project will deliver a series of integrated technical models for nitrogen, phosphorus, and pesticide non-point source pollutant interception and reduction in the lower Yangtze region, achieving over 30% reduction in nitrogen and phosphorus pollution loads while controlling environmental pollution and agricultural product quality decline caused by improper input use and maintaining high stable grain yields. The project will establish one pesticide biodegradation microbial agent production line with annual capacity of 30 tonnes, reducing pesticide residues by over 30%. Agricultural waste utilization

rates will increase to 95%, with straw return effectively improving soil organic matter content, enhancing soil physical properties, maintaining ecosystem balance, and achieving sustainable land productivity. For Cd, Pb, and Cu contamination from small enterprises and copper mines, the project will develop efficient ecological remediation and safe utilization technical systems and procedures for different pollution levels, reducing heavy metal bioavailability by over 50% and providing a replicable systematic solution for heavy metal-polluted farmland, thereby significantly advancing heavy metal pollution risk control in the region and providing important references for national farmland remediation and food security.

Socioeconomic and Environmental Benefits

Based on a comprehensive demonstration area of 1,333 hectares, the project will save over 200 tonnes of fertilizer annually and process approximately 10,000 tonnes of straw waste each year. It will ensure safe agricultural production and enable approximately 10% green food production, reducing production costs and increasing farmer income. The project will create employment opportunities in straw return and supporting agricultural machinery management, organic fertilizer production, and integrated nitrogen-phosphorus-water-pesticide management, while enhancing farmers' awareness of efficient resource utilization and protection. It will also drive development of related industries including clean agricultural production, environmentally friendly fertilizers, pesticide residue degradation microbial agents, and hyperaccumulator plant resource utilization equipment, ultimately achieving coordinated development of environment, resources, food, and health.

Note: Figure translations are in progress. See original paper for figures.