

# Key technology for deep liquid fertilizer applicator and its application, NEAU



## Technical team for intelligent paddy field technology and equipment

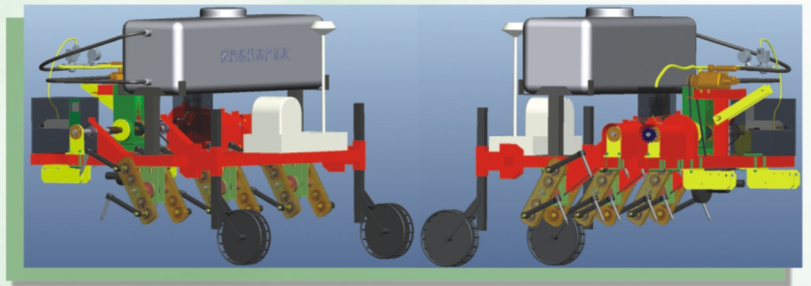
Combining the characteristics of rice planting areas in Northeast China, the team conducted a lot of generic and key technology researches for rice straw deep buried and whole straw returning device, ridge construction device, precision hill-direct-seeding metering device, seedling transportation and seedling protection, weeding and rice combine harvester. A series of production technology and equipment for grain drying and non-destructive testing were studied. More than 10 types of rice production machines have been developed, and some of them have been applied in practical production.

The team consists of four professors, two professor-level senior engineers, two senior engineers, eight PhD candidates and 30 master candidates. Among them, one is the scientist in the position of National Rice Industry Technology System, one is the provincial famous teacher in teaching and one is the research leader in provincial leading talents echelon. There are two academic backbones of Northeast Agricultural University (NEAU) and one "Talented Youth" in the East Agricultural Scholars Program. The team has published more than 50 academic papers, including more than 30 SCI/EI-indexed articles in the past three years. The team has obtained 22 nationally authorized invention patents, of which more than 10 have been transformed or applied; more than 10 national and provincial research projects have been presided over, with an accumulated funding of more than 25 million Yuan.

## Chief Scientist: Prof. Jinwu Wang

Dr. Jinwu Wang is a professor, doctoral supervisor and leading scientist of Intelligent Paddy Field Equipment and Technology Team at Northeast Agricultural University. Currently he serves as the scientist of National Modern Agricultural Industry Technology System, the expert of Heilongjiang Provincial Modern Industry Technology Collaborative Innovation System, the expert of Grain Production Increasing Mode of Ministry of Agriculture and Rural Affairs of the People's Republic of China, the Excellent Workers of Provincial Education System, Heilongjiang Provincial Innovation and Entrepreneurship Instructor, Heilongjiang Provincial Excellent Graduate Supervisor.

Prof. Wang received Bachelor's degree, Master's degree and PhD degree in Agricultural Mechanization Engineering at Northeast Agricultural University in 1994, 1997 and 2001 respectively. In 2003, he entered Postdoctoral Station of Agricultural Engineering Postdoctoral Station, Zhejiang University. In June 2006, he worked at Ibaraki University in Japan as a senior visiting scholar. He continued to study at Hong Kong Polytech University in April 2012. Prof. Wang has been appointed as one of the Experts of Teaching Material Construction Committee of China's Ministry of Agriculture and Rural Affairs, a Director of Chinese Society of Agricultural Engineering, Vice Chairman of Harvest Branch of the Chinese Society for Agricultural Machinery, Vice Chairman of Agricultural Mechanization Electrification Branch of Chinese Society of Agricultural Engineering, Executive Director and Deputy Secretary-General of Heilongjiang Provincial Society for Agricultural Machinery, and the Director of Heilongjiang Provincial Society of Agricultural Engineering. He serves as Editorial Board Member of international journals such as IJABE (SCI), Transactions of the Chinese Society of Agricultural Engineering (EI), Journal of Agricultural Mechanization Research, Agricultural Equipment and Vehicle Engineering, and Agricultural Engineering Technology, as an excellent peer reviewer of international journals such as ASABE (SCI), Transactions of the Chinese Society of Agricultural Engineering (EI). He is mainly engaged in the scientific research and teaching in the fields of agricultural paddy field equipment theory and technology and basic theory and key technology for variable-rate and deep liquid fertilizer applicator. A series of technologies and equipment for rice straw deep buried and whole straw returning device, ridge construction device, precision hill-direct-seeding metering device, seedling transportation and seedling protection, weeding and rice combine harvester were researched and developed. More than 20 kinds of machines and tools have been invented and improved. Some of the achievements have been transformed and applied in practical production, generating a total economic benefit of more than 10 million Yuan (Technology transfer and sales from deep liquid fertilizer applicator, rice straw deep buried and whole straw returning device, modified rice combine harvester).



## Projects, outcomes and awards

Prof. Wang undertook as Principal Investigator and completed more than 30 projects, such as the National Key Research and Development Plan, National Science and Technology Support Program projects, projects supported by National Natural Science Foundation of China, National "863" Plan sub-topics project and provincial and municipal key projects. He presided over 6 research projects at the national and provincial level, and some of the achievements have been industrialized and applied. Prof. Wang has published over 130 academic papers with first author and corresponding author, of which more than 60 are included in SCI/EI, receiving over 1000 cites. He published three academic monographs, with one



chief editor one deputy editor in chief and 8 national planning textbooks. Among them, two as chief editors have been awarded Excellent Textbooks for Agricultural Education, and the other two as deputy chief editor have been listed as National Quality Textbooks. 60 patents were authorized, including 31 invention patents, 29 utility models, 11 software copyrights, and 5 patent technology transformation.

Prof. Wang and his team have received one first prize and one second prize of Heilongjiang Science and Technology Award, one first prize of Heilongjiang Teaching Achievement Award, one prize of Heilongjiang Natural Science and Technology Academic Achievement Award, one second prize of Harbin Science and Technology Award, one first prize of Heilongjiang Science and Technology Award, one second prize of China Agricultural Machinery Science and Technology Award and China Award as the primary accomplisher. He was also awarded one first prize for agricultural science and technology, one first prize for teaching achievement in Heilongjiang Province and two second prizes, and one first prize for outstanding scientific research achievements in Social Sciences in Heilongjiang Province.

## Contact information

Contact: Jinwu Wang

Telephone: +86-451-55191188 Cell phone: +86-13904619325 Email: jinwu@163.com

Address: College of Engineering, Northeast Agricultural University, 600 Changjiang Road, Xiangfang District, Harbin, 150030, China



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## Main research contents

In recent years, excessive application of chemical fertilizers has led to soil pollution and degradation, which seriously threatens the food and environmental safety of China. The deep application of liquid fertilizer can effectively improve the use efficiency of chemical fertilizer, reduce environmental pollution and slow down the progress of soil degradation, which is according with the strategic goal of "Two Reduction" proposed by China's Ministry of Agriculture and Rural Affairs. At present, the output and usage of liquid fertilizer in China are increasing annually, with a growth rate of more than 6% each year. However, the lack of deep liquid fertilizer application technology and supporting equipment of liquid fertilizer seriously restricts the application and promotion of liquid fertilizer. Based on this, the team led by Prof. Wang put forward the theory and technology of the deep liquid hole-pricking fertilizer applicator, invented a series of rod-type and planetary elliptical gear transmission hole-pricking mechanism, and put forward a parameter design method for the trajectory of the planetary elliptical gear transmission hole-pricking mechanism, developed a software for optimizing and analyzing various parameters, invented a series of liquid fertilizer distributors and converters. A fertilizer transporting system which applies liquid Nitrogen, Phosphorus and Potassium fertilizer, variable-rate fertilization and wireless monitoring was developed, and a series of deep liquid fertilizer applicators with international advanced level were developed.

## Funded projects

National Natural Science Foundation of China: Key Technology and basic theory for deep liquid fertilizer applicator

National Natural Science Foundation of China: Innovative design and mechanism study on oblique rotary hole-pricking fertilization mechanism of liquid fertilizer in crop root zone

Provincial Fund for Overseas Students: Key technology for deep liquid fertilizer applicator

National Science and Technology Support Projects in the Twelfth Five-Year Plan:

Experimental Demonstration of Mechanization Technology for Soil Fertility Cultivation in Northeast China

Provincial Technological Project of Science: Development of Intelligent Digital Control Liquid Fertilizer Applicator

## Innovations

1. The technology for efficient deep liquid hole-pricking fertilizer applicator and a method of inverse parameter design which is based on Bessel Curve fitting point trajectory were put forward for the first time, a series of rod-type and planetary elliptical gear transmission hole-pricking mechanism with international advanced level were developed, which realized high-efficiency, stable and deep application operation and overcome the technical bottleneck of the mechanical damage caused by the pricking mechanism to the plants.

2. The technology of intermittent precise control of the hole pricking application was first invented, and a series of distributors synchronously operated with the hole-pricking mechanism were invented. The technical difficulties of precise control of the hole-pricking mechanism in soil spraying and unearthed stopping spraying were overcome. Synchronized positive and negative rotation differential technology was first invented, and a series of liquid fertilizer circuit converters were invented, which solved the problem of fertilizer discharging pipeline winding and improved the efficiency of hole pricking application.

3. A fertilizer transporting system which meets the need of discharging mixed liquid Nitrogen, Phosphorus and Potassium fertilizer was first invented, was initiated to overcome the difficult problem of precise application of liquid fertilizers in multi-dimensional soil layers. The automatic diagnosis technology of multi-line CAN fertilizer discharging system was put forward. The wireless monitoring system of variable fertilization control and fertilizer discharging pipeline blockage was invented. The problem of precise variable fertilization and timely feedback control of fertilizer discharging information was solved.

4. Based on the technology that mentioned above, a series of deep liquid fertilizer applicators were developed. Accurate and quantitative deep application of fertilizer can be achieved. The depth of fertilization can reach 8-12 cm. The effective use efficiency of fertilizer can be increased by 32.67%-58.96% and the chemical fertilizer use can be saved by 18%-23%.

## Support and application promotion

The team has applied for 45 national invention patents, among which 21 invention patents and 5 utility model patents were authorized, and 7 software copyrights were gained. The team has published 53 academic papers funded by the projects, including 23 papers in EI and 3 monographs, which was cited 369 times. In 2015-2017, the deep liquid fertilizer applicator has been sold 94 million yuan and added 9.44 million yuan in profit, saving fertilizer costs totaled 3.2 million yuan. With the increase in the production and use of liquid fertilizer, the effect of the results will be more prominent, and the development and application prospects are huge.

## Contact information

Contact: Jinwu Wang

Telephone: +86-451-55191188 Cell phone: +86-13904619325 Email: jinwuw@163.com

Address: College of Engineering, Northeast Agricultural University, 600 Changjiang Road, Xiangfang District, Harbin, 150030, China

