Analysis of Influencing Factors on Seeding Uniformity of Precision Seeder

Detang Zheng[1,2], Xinxue Zhao[2]
[1](College of Mechanical Engineering and Automation, Liaoning University of Technology, China)
[2](College of mechanical and electrical engineering, Shandong University of Aeronautics, China)

ABSTRACT: *Precision seeding technology is the most critical part of agricultural mechanization production, and it is also an important means to achieve cost reduction and efficiency increase. Accurate control of seed filling, seeding and landing is the core of precision seeding technology and the key to uniform seeding of precision planter. From the point of view of each link of seed movement, this paper summarizes the research status and progress of seed movement control methods in single seed precision sowing machinery at home and abroad in three stages of seed filling, seed guiding and seed throwing. The technical problems that should be solved in the process of precision seeding are pointed out, and the development trend of seed motion control method of precision seeder in the future is prospected according to the above technical problems and the production status in China, so as to provide reference for the research of precision seeding technology and the innovative design and application of equipment.*

KEYWORDS *-seed filling, seeding ,landing, precision seeding technology, movement control*

I. INTRODUCTION

China regards food security as the top priority of governing the country. Food security is related to national security and social stability. Especially since 2020, the COVID-19 epidemic and the ever-changing international situation have impacted the food security of all countries in the world, which further proves that food is the foundation of national survival and development.

With the development of agricultural science and technology and the advent of many intelligent agricultural machinery and equipment, modern agriculture is developing in the direction of high precision and high efficiency. Precision seeding technology, high efficiency tillage and soil preparation technology, precision plant protection technology, low loss harvesting technology and so on. As the starting point of field agricultural production technology, precision seeding technology has become an important guarantee for crop growth and development and high yield and harvest in modern agriculture. Nowadays, many crops, including wheat, corn and soybeans, have realized mechanized precision sowing. In the process of mechanized precision seeding, seeding technology is the most critical part, which determines the quality of seeding operation and crop yield. In recent years, researchers at home and abroad have done a lot of research on seeding technology and equipment, and explored various seeding principles such as mechanical, pneumatic or mechanical-pneumatic combination. According to different seed characteristics and applicable seeding principles, the corresponding seeding device structure design was carried out, and the filling process and seeding process of the seeding device were studied in depth. With the help of computer technology and modern design methods, the simulation and structural optimization design of the seeding process were carried out, and the reasons for the replay, missed seeding and the uniformity of the seed belt after seeding were explained in detail.

Precision seeder seeding generally goes

through three processes : seed filling, seed guiding and seed metering. The purpose of this paper is to summarize the research status and progress of precision seed control methods at home and abroad from the three stages of seed filling, seed guiding and seed throwing. It points out the technical problems that should be solved in the process of precision seeding, and looks forward to the development trend of precision seeding in the future in combination with the production status in China.

II. RESEARCH PROGRESS ON SEED CONTROL METHODS IN FILLING STAGE OF PRECISION SEEDER

The purpose of studying the seed control method in the filling stage is to enable the precision seed metering device to discharge continuous and uniform single seed, and to improve the filling rate and single seed rate. Du et al. [1] optimized the structural parameters of the seed-metering plate by EDEM, and increased the spiral disturbing strip on the seed-metering plate to enhance the population kinetic energy and improve the seed filling rate. Fu Hao et al. [2] uniformly distributed the seed-disturbing table on the upper surface of the seed-picking plate. Through the rotation of the seed-disturbing table with the seed-picking plate, they promoted the corn grains in the seed-filling area, destroyed the population force chain, adjusted the grain posture, and reduced the probability of seed-filling failure due to arching and overhead. In order to improve the seed-filling performance of the seed-metering device, Meng Hua et al. [3] added a fixed disturbing ring on the inner side of the seed-metering plate, and collided the seed group around the hole by the disturbing ring to increase the activity of the seed group and reduce the formation of the force chain of the seed group, thereby improving the seed-filling performance. Based on the traditional air-suction seed metering device, Liu Zeqi [4] used the positive pressure airflow at the bottom of the seed supply room to disturb the population, so that the population was in a boiling state. Due to the flat structure of the flat seed, the suspension attitude of the seed changes under the action of air blowing disturbance. The attitude of the seed is adjusted by rationally designing the structure and working parameters of the seeding system, and the flat surface of the seed is kept parallel to the suction hole surface at the moment of adsorption, and the relative motion of the seed and the suction hole in the flat surface is zero, so that the flat seed is in an ideal adsorption state.

Tian Jianfeng et al. [5] designed a sheet rubber seed cleaning brush. Compared with the traditional brush, the sheet rubber seed cleaning brush can avoid the blockage caused by the small seed squeezing into the brush, and can well block the seeds outside the nest eye without injuring the seeds. The seed cleaning effect is good, which effectively reduces the replay rate of the nest eye wheel seed metering device. The air-suction curved serrated seed cleaning mechanism was simulated and designed. Li et al. [6] proposed a method of bilateral seed clearing structure. The upper seed clearing structure squeezes and collides the seeds to remove part of the seeds, and the seeds squeezed to the lower side are further cleared by the lower seed clearing structure. The mathematical modeling of the cleaning process was carried out to determine the key parameters of the upper and lower sides of the cleaning knife. The results showed that the qualified rate of the seed metering device was generally increased by more than 5 percentage points by using bilateral cleaning. Ding et al. [7] established a mathematical model for seed cleaning through the area ratio of seeds and type holes. It was found that the re-absorption was mainly caused by the change of seed attitude during the adsorption process. In order to ensure that the seeds falling back to the filling area, the installation position of the seed cleaning mechanism was calculated. The analysis of the number of serrated teeth and the seed cleaning curve, combined with the simulation design of the air-suction curve serrated seed cleaning mechanism.

III. RESEARCH PROGRESS ON SEED CONTROL METHODS OF PRECISION SEEDER IN SEED GUIDING STAGE

In the seeding process of precision seeder, the variation of seed spacing caused by seed movement is the key factor affecting the uniformity of seed spacing [8]. In order to solve the problem of seed bounce during sowing, the existing technology mainly sets up a seed guide tube with a special curve or a secondary seed throwing mechanism with a special structure to ensure that the speed of the seed falling into the seed bed is partially offset by the forward speed of the seeder,

thereby reducing the bounce of the seed. Cao Xianchao et al [9] used EDEM software to simulate the movement of seeds in the seed guide tube, and obtained the trajectory of seeds in the seed guide tube, and pointed out that when the uniform operation, the uniformity of plant spacing depends on whether the movement time of adjacent seeds in the seed guide tube is consistent, whether the position and angle of the seed shooting out of the seed guide tube are consistent, that is, the uniformity of plant spacing is mainly affected by the seed migration system and landing bounce. Cao Jianxin et al [10] proposed a method to constrain the degree of freedom of seed motion and guide the direction of seeding, aiming at the problem of inconsistent seeding points and poor uniformity of seed spacing under high-speed working conditions of corn attitude control-driven seed metering device. A guided seeding mechanism was designed. By reasonably planning the trajectory of the seed to be cast, the motion and force of the seed to be cast were analyzed, and the key structural parameters and value range of the guided seeding mechanism were determined. Liu Rui et al. [11] designed a positive pressure airflow assisted blowing seed guide device. The DEM-CFD coupling simulation test was used to analyze the influence of the inlet chamber structure on the airflow field, seed movement speed and seed movement trajectory of the seed guide device. The key structural parameters of the inlet chamber, mixing chamber and seed guide chamber of the seed guide device and the curve of the seed guide device were determined.

Han Jianfeng et al. [12] designed a combined double-row wide-strip seed guide device for non-contact soil sowing wheat to solve the problem of broken bars caused by the coupling effect of sticky soil and straw returning when mechanized strip sowing of wheat in rice stubble field. The working principle of the seed guide device was expounded, the mechanical model of wheat in the process of seed separation and introduction was constructed, and the key factors affecting the uniformity of seed guide were theoretically analyzed. Feng [13] designed a dial belt seed guide device suitable for high-speed operation to solve the problem of poor uniformity of seed spacing of corn precision seeder under high-speed operation conditions. The device can effectively restrain the degree of freedom of seeds in the process of seed guide, realize fully constrained seed guide, accurately control the seed migration trajectory and reduce the height of seed throwing, and reduce the bounce and collision of seeds in the process of seed guide. Ma Chengcheng et al [14] took the belt-type maize high-speed seed-guiding device with seed-receiving mechanism as the research object, analyzed the mechanism of rotating and clamping the seed, established the grain dynamics model in the process of picking, transporting and discharging the grain by the finger wheel, and put forward the improvement method of adding the herringbone pattern on the surface of the finger. It was clear that the main factors affecting the stability of seed-receiving and the accuracy of the grain entering the seed cavity were the wheel center distance, the rotation speed of the finger wheel and the length of the finger.

IV. RESEARCH PROGRESS ON SEED REGULATION METHODS IN SEEDING STAGE OF PRECISION SEEDER

As the end link to keep the seeds in a uniform and orderly state during the sowing process, seed dropping plays an important role in the uniformity of the final field distribution of seeds [15]. Seed dropping and landing is the whole movement process of seeds from leaving the seed guide device to resting at a certain position in the seed furrow. The study of the motion characteristics of the moment of collision between seeds and soil is the basis for eliminating the bounce and rolling of seeds. Researchers at home and abroad have made some explorations on the collision relationship between seeds and soil. For example, by analyzing the trajectory of seeds leaving the seed metering device, the influence of collision speed and angle, soil surface characteristics and seed type on bounce height and displacement is found. Wang et al. [16] used the uniform design method to test the bouncing rolling displacement of the disc opener seeds after touching the soil, and established the regression equation between the ditching angle of the machine and the width of the covering plate and the bouncing rolling of the grains. Ma Xu et al. [17] studied the seed bouncing and rolling after falling into the furrow, and established a mathematical model of table bottom velocity, angle influencing

factors and seed bouncing displacement by quadratic general rotary design test method.

V. SUMMARIZED AND PROSPECTED

With the development of large-scale agricultural production in China, large-scale operators pay more and more attention to the operation efficiency of precision seeders while paying close attention to the yield per unit area. Agricultural production puts forward higher requirements for precision seeding technology, that is, to improve the operation efficiency as much as possible on the premise of ensuring the quality of seeding. How to further improve the working speed of precision seeder in China has become a research hotspot in the field of precision seeding.

The evaluation of seeding performance is developing towards high speed, variable and high performance. With the development of agricultural production to intensive, large-scale and high-efficiency, high-speed precision seeder has become the production demand, and the seeding technology that adapts to the seeding operation speed greater than 12km / h has become the key technology that needs to be broken through. In general, modern agriculture is developing towards precision sowing with uniform distribution of row spacing and reasonable regulation of planting density, and the research on variable seeding technology will be on the rise. At the same time, the operation stability of the seed metering device under complex working conditions in the field, the prediction of the falling position of crops with strict row spacing requirements, and the technology of smooth migration and seed guidance are research difficulties.

REFERENCES

[1] X Du, C L Liu, M Jiang, Design and experiment of self-disturbing inner-filling hole-wheel corn precision seed metering device, *ACTA AGRICULTURAL ENGINEERING, 35 (13),*2019,23-34.

[2] H Fu, X J Zhang, Z L Shi, Design and test of disc-type corn precision seed metering device with side-filling groove,*Journal of Huazhong Agricultural University,42(05),*2023,229-239.

[3] H Meng, X Wang, X H Li, Design and experiment of soybean seed metering device assisted by fixed disturbance,*Chinese Journal of Agricultural Machinery Chemistry, 44 (06),*2023,18-25.

[4] Z Q Liu,*Experiment and Research on Air-suction Seed Metering Device for Flat Seeds Based on Air-blowing Disturbance,*master thesis,Shandong University of Technology,Zibo, Shandong, China,MA,2023.

[5] J F Tian, L R Shi, X P Yang, Experimental study on the performance of Codonopsis metering device,*Research on agricultural mechanization, ,46 (12),*2024,140-147.

[6] Y H Li, L Yang, D X Zhang, Design and experiment of bilateral cleaning device for air-suction corn precision seed metering device,*Agricultural Machinery Journal,52(07),*2021, 29-39.

[7] L Ding, L Yang, D X Zhang, Parametric design and test of cleaning mechanism of air-suction corn seed metering device,*Agricultural Machinery Journal,50(09),*2019,47-56.

[8] F Liu, R C Du. Built-in double-position seed-drop dibbler,*Journal of Agricultural Machinery,42 (08),*2011,35-40 + 29.

[9] X C Cao, D S Yang, X W Du, Huang Wenlong. Design and experiment of air-suction seeding unit based on EDEM,*Chinese Journal of Agricultural Machinery Chemistry,44(10),*2024,8-14.

[10] J X Dong, X J Gao, S L Zhang,Design and experiment of guiding and throwing mechanism for corn attitude-controlled seed-metering device,*Journal of Agricultural Machinery,54 (10),*2023,25-34.

[11] R Liu, Y G Liu, Z J Liu,Research on positive pressure air flow assisted blowing and guiding device of corn high-speed precision seeder,*Agricultural Machinery Journal,54 (07),*2023,156-166.

[12] J F Han, J H Du, X Gu, Design and experime nt of wheat split-lead combined double-row w ide strip seed guide device,*ACTA AGRICULT URAL ENGINEERING,39 (11),*2023,35-46.

[13] Z H Feng,*Design and test of pneumatic high-speed corn precision seeder dial belt seed guide device,*master thesis,Heilongjiang Bayi Agricultural University,Daqing City, Heilongjiang Province, China,MA,2023.

[14] C C Ma, S J Yi, G X Tao, Mechanism analysis and parameter optimization of high-

speed belt corn seed guide device,*Agricultural Machinery Journal, 54 (07)*,2023, 134-143.

[15] L B Wang, H Y Yang, Q J Wang,Design and experiment of wheat airflow-assisted straight-line seeding device,*Agricultural Machinery Journal, 55 (06)*,2024, 111-120.

[16] W Wang, X Ma, R Yuan, Experimental study on bouncing rolling displacement of seeds based on uniform design ,*Journal of Jilin Agricultural University, (06)*,2006, 694-696 + 701.

[17] X Ma, H Y Yu, H K Yang, Measurement and modeling of bouncing rolling displacement of seeds falling in seed furrow,*Journal of Agricultural Machinery, (S1)*,1998,62-66.