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Research on a Universal No Tillage Seeder for Wheat and Corn

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Abstract: This article focuses on the problems of low operating efficiency, multiple soil working components, poor trafficability, and poor adaptability of current domestic no tillage seeders. Combining with the agricultural mode of planting wheat and corn in the double cropping area of the year, the structure of the seeder is optimized, and an intelligent wheat and corn universal no tillage seeder with one machine, dual use, deep loosening, and layered fertilization is studied and designed.

1. Overview

China is a major agricultural country, and the status of wheat and corn as the main food crops is self-evident. As a key planting machine, sowing quality directly affects crop yield and agricultural production cost. Improving sowing quality, developing sowing technology, reducing production cost and improving sowing efficiency are urgent requirements of modern agriculture. This article focuses on a series of problems with current domestic no tillage seeders, combined with the agricultural mode of planting wheat and corn in the double cropping area of one year, optimizes the structure of the seeder, and develops an intelligent wheat and corn universal no tillage seeder with one machine dual use, deep loosening, and layered fertilization.

2. Current research status

With the continuous improvement of mechanised agriculture, the traditional no tillage sowing method has been difficult to meet the needs of modern agricultural development. In important crops such as wheat and corn, the application of zero tillage sowing technology can reduce soil erosion, improve agricultural production efficiency and quality. Therefore, researching non tillage seeders for wheat and corn has become an important research direction.

At present, there have been many representative studies on the design, optimization, and application of no tillage seeders. The research on zero tillage seeders for wheat and corn can be mainly divided into two categories. One is the mechanical structure design category, which optimizes the structural form of the zero tillage seeder to meet the requirements of improving performance. Xing Renjie et al. (2023) analyzed the current manufacturing and use of grooved discs, providing solutions from three aspects: new material research, heat treatment processes, and surface

strengthening treatment[1]. Hao Zhihao et al.(2023) established a discrete element model of a tool straw soil coupling system to simulate the rupture and deformation of straw, and compared and analyzed the parameter changes of straw under the action of standard knife and trapezoidal straight knife under rotary tillage operation conditions, proposing an optimized structure[2]. Ran Yunliang(2015) conducted design research on the 2BMJF-4/14 dual purpose no tillage seeder for wheat and corn, optimized the planting mode for wheat and corn, and designed and developed a dual purpose no tillage seeder for corn and wheat[3]. It can complete multiple operations such as seed bed stubble removal, furrow fertilization, sowing, soil covering, and compaction in one go, forming a furrow shape after compaction, and enhancing soil water storage capacity. Peng Lixin et al.(2022) conducted research on deep loosening devices and fertilization and sowing devices through three-dimensional modeling, optimized mechanical structures, and explored soil compaction issues, providing support for subsequent theoretical analysis of the entire machine model[4].

The second is system control, which optimizes and improves the supporting operating system and intelligent system of the zero tillage seeder to improve work efficiency. Yu Shouxian et al.(2023) conducted research on the depth monitoring system of the zero tillage seeder based on microcontroller and wireless communication technology, analyzed the functions and selection of various production components, and finally verified the field operation performance of the intelligent monitoring system of the zero tillage seeder through field experiments[5]. Xie Baiyi et al.(2023) developed an automatic monitoring system for no tillage seeders based on LabVIEW and conducted field experiments using sowing quality as an evaluation indicator[6].

At present, research on zero tillage seeders for wheat and corn still faces some shortcomings:(1) low efficiency of machine operation, multiple soil working components, high work resistance, high power consumption, low equipment efficiency and operator income, and low enthusiasm of farmers to purchase agricultural machinery[7]; (2) Poor passability of machinery, severe blockage and entanglement of straw, and difficulty in handling hard corn stubble, resulting in a decrease in sowing quality; (3) The utilization rate of machines and tools is low. Currently, no tillage sowing machines can only carry out wheat sowing operations and cannot be used multiple times; (4) The adaptability of the machines and tools is poor. The production conditions in the wheat and corn two cropping areas are different in different regions. The dry farming area has less straw coverage, while the irrigation area has more straw coverage, and the soil quality is also different in different regions. The adaptability of the zero tillage seeder operation is poor, and the application of intelligent detection devices is limited, relying solely on manual inspection of the operation quality, which is labor-intensive and time-consuming, making it difficult to ensure the operation quality.

Therefore, a no tillage seeder with straw treatment device has been developed for wheat and corn that ripens twice a year, which can sow both wheat and corn[8]. The problem of low seedling rate caused by the mixing of straw and soil has been fundamentally solved through the seedling belt vertical rotation and straw breaking device; By using intelligent deep loosening, layered fertilization device, and vertical rotation straw cleaning device, multiple operation links are integrated for compound operation, real-time monitoring, and ensuring sowing accuracy; It can adapt to the integration of agricultural machinery and agronomy, with one machine for multiple purposes, increasing the use time of machinery, improving the utilization rate of machinery, reducing the investment of agricultural machinery equipment by agricultural machinery households, and is more conducive to the full mechanization of wheat and corn.

3. Development of a new type of seeder

(1) Introduction to the overall structure

The entire machine adopts a modular design, consisting of a frame part, a suspension part, a cylindrical grass distribution device, a fertilization device, a stabilizer part, a sowing box, and a fertilization box. The machine can complete multiple processes such as grass cleaning and grass distribution (straw), deep loosening, layered fertilization, trenching, sowing, soil covering, and compaction in one operation.

Working principle: The tractor pulls the floating seeder for operation, and the tractor's power output shaft is driven by a universal joint to drive the rake to work, driving the cylindrical grass dividing device to complete the work of soil crushing, seedling bed sorting, and straw clearing; Drive the upper outer groove wheel seeder and fertilizer discharger through chain transmission. The discharged fertilizer is applied to the soil through a deep loosening and layered fertilization shovel, and the discharged seeds enter the seeder device through a conduit. After sowing is completed, they are compressed by a compactor. The deep loosening and directional layered fertilization shovel is used for deep loosening and directional layered fertilization, the seeder device completes the functions of ditching and sowing, and the seeder can switch between wheat and corn sowing.

The rack design is adjustable and can adjust the height of the rear seeder and compactor to meet the requirements of different ground conditions. For example, in soft and hard soil areas, it is necessary to adjust the seeder and compactor simultaneously. After completing the design of each part, the machine is assembled with welding, connecting standard parts, etc. (Figure 1).

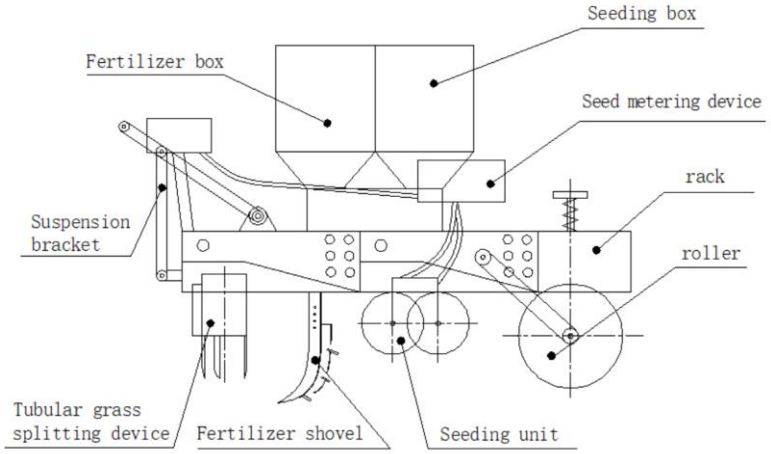

Figure 1: Overall Structure Diagram

(2) Design of a universal seed metering device

The seed metering device adopts a mechanical outer wheel groove type, which can switch between wheat and corn sowing, and is versatile in one machine. When sowing wheat, the principle is the same as the ordinary outer wheel groove type, and the sowing speed can be adjusted by adjusting the shaft speed; When sowing corn, the device is pushed to the other side and a shaped hole is used for precise sowing. Controlling the wheel speed can control the sowing efficiency.

(3) Design of deep loosening layered fertilization shovel

Using a specially designed deep loosening fertilization shovel, a layered fertilization device can be installed on the deep loosening shovel, which can be designed with three layers of fertilization ports or multiple layers of fertilization ports for full layer fertilization to achieve directional fertilization. Layered fertilization can fully exert fertilizer efficiency, and wheat has strong growth potential.

(4) Design of Vertical Rotary Barrel Straw Cleaning Device

A specially designed cylindrical straw cleaning device is used, which is driven by a power driven rake to rotate the grass and remove the straw. The soil is then crushed by the soil cutter under the drum and the seedbed is sorted. It can effectively clean the straw in the seedling belt and form a seedbed without changing the soil structure. The vertical rotary tube shaped straw cleaning device can not only separate the surface straw and weeds from the seedling bed and store them on the ridge, but also handle the root stubble to ensure that there is no blockage during sowing and fertilization.

(5) Design of a wide seedling belt seeder

Using a widened disc type wide seedling belt seeder, two sets are combined before and after to achieve the needs of wide seedling belt sowing. The double disc seeding unit adopts a parallel four link mechanism for single body profiling. When the ground surface is uneven, the double disc maintains horizontal upward and downward movement through springs, maintains consistent soil entry angle, and has good trench stability, ensuring the uniformity of seeding depth.

(6) Design of waist drum type compactor

A specially made waist drum type compactor is used to achieve compaction of the wide seedling belt and prevent secondary soil covering caused by the collapse of the ridge belt, which affects the sowing quality. The compactor adopts a combination type and is separated by a sleeve in the middle, which can be adjusted according to the actual row spacing.

(7) The application of intelligent electronic monitoring equipment

Traditional seeders follow specialized personnel behind the seeder to monitor the quality of fertilizer flow in real-time to avoid large-scale missed seeding. Additionally, seeders equipped with electronic monitoring equipment allow drivers to monitor the quality of operations through the display screen in the driver's cab, reducing manual use and improving operational efficiency.

(8) Main technical parameters

Main technical specifications and parameters: The overall size is 1.9m × 2.5m × 1.57m (length × wide × High), with 6 rows of wheat and 6 rows of fertilizer. The width of the seedling belt is ≥ 18cm, and the depth of cultivation is ≥ 18cm. The seed metering device is an external groove wheel type, with a deep loosening of ≥ 25cm and a vertical rotation depth of 18-20cm. The straw cleaning rate of the seedling belt is ≥ 80%, the seed leakage rate is ≤ 3%, the fertilizer leakage rate is ≤ 3%, and the supporting power is ≥ 88 KW. The working speed is 2-6 km/h.

4. Characteristic analysis

One is the research and design of a vertical rotation straw cleaning device. At present, the no tillage seeder has been difficult to break through in the field of removing straw from the seedling belt. The traditional rotary blade method of removing straw makes it difficult to remove the straw from the soil in the seedling belt during the formation of the seedling bed operation, which affects the emergence rate. The project adopts a vertical rotating cylinder straw cleaning device, which subverts the existing no tillage sowing method of removing straw from the seedlings. It can effectively clean the straw from the seedlings and form a seedbed without changing the soil structure. This ensures that the seeds germinate in the soil and the emergence rate is not affected.

The second is the design of intelligent electronic monitoring devices. Traditional seeders follow specialized personnel behind the seeder to monitor the quality of fertilizer flow in real-time to avoid large-scale missed seeding. Additionally, seeders equipped with electronic monitoring equipment allow drivers to monitor the quality of operations through the display screen in the driver's cab, reducing manual use and improving operational efficiency.

The third is the design of a deep loosening layered fertilization device. The traditional no tillage seeder has been operating for more than two years and must perform deep loosening operations on

the cultivated land, otherwise it will cause soil compaction and reduce yield. This machine is designed with deep loosening and layered fertilization devices directly connected to the seeder for integrated compound operation, and is equipped with layered directional fertilization devices, greatly improving work efficiency and fertilizer efficiency.

After the completion of the prototype production of this project, field experiments were conducted at the Greenfield Agricultural Machinery Cooperative Planting Base in Weicheng District, Weifang. The planting efficiency was greatly improved, and the machines integrated multiple operation links such as intelligent deep loosening, layered fertilization, vertical rotation to clear straw, and wide seedling belt no tillage precision sowing for repetitive operations. The field operation was in good condition, with low failure rate, cost saving and efficiency increasing, achieving the expected design goal. Currently, more than 200 acres of work have been completed, each acre can reduce costs and increase efficiency by 200 yuan. If widely promoted and used, the economic and social benefits are significant.

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