INFLUENCE OF SOIL MOISTURE CONTENT ON MAIZE SOWING MONITORING SYSTEM

K.K. CHEN[1,2], Y.W. YUAN[2], B. ZHAO[2], L.M. ZHOU[2], K. NIU[2], M.H. XU[2], C.W. WANG[2], X. JIN[3], Y.J. ZHENG[1, *]

Aiming at the problem that the soil moisture content of no-till land is difficult to manually measure the missed seeding, re-seeding, and sowing depth of no-tillage sowing operations, this paper combines sensor technology to design a quality monitoring system for corn sowing operations. Field experiments were conducted to collect information on the operation of no-tillage planters in cultivated land with different moisture contents and to study the effects of different soil moisture contents on the quality of sowing operations. According to the test results, when the planter operates on three kinds of arable land with different moisture contents, the sowing quality monitoring system can monitor the sowing and sowing depth accuracy of more than 92%; The monitoring accuracy of sowing and its depth is higher than that of no-tillage land for corn and wheat, Which rech more than 96%. This study provides a reference value for improving the accuracy of the no-tillage planter's quality monitoring system.

Keywords: corn; sensors; sowing operation quality; soil moisture content; monitoring accuracy

1. Introduction

China is a big agricultural country, which corn is the main food crop [1-2]. In recent years, with the decrease in farmland soil fertility and organic matter year by year, conservation tillage has attracted more and more attention as an advanced agricultural tillage technology [3-4]. At the same time, with the rapid development of intelligent agricultural equipment, higher requirements have been put forward for the operation quality of no-till planters [5-6].

In the agricultural production process, sowing is one of the most important links. The quality of sowing is directly related to the final yield of the crop. The existing planters in my country will inevitably have problems such as missed seeding and replaying during the operation process [7]. Most of the seeders used

[1]College of Engineering, China Agricultural University, Beijing, 100089, China
[2]The State Key Laboratory of Soil, Plant and Machine System Technology, Chinese Academy of Agricultural Mechanization Sciences, Beijing,100083, China
[3]College of Agricultural Equipment Engineering, Henan University of Science and Technology, Luoyang, 471003, China
[*]E-mail: zyj@cau.edu.cn

are mechanically and pneumatically [8]. Due to the influence of the sealing and seeding performance of the seeder, there are problems such as missed seeding and replaying in the working process of the seeder. It is difficult to detect in time only by human audiovisual, which will result in poor quality of sowing operations [9-11].

The planter will be affected by various external factors during the working process. The relationship between the soil rheological property model and the influencing factors was determined by Hu Jun through experimental methods [12]. It was found that when the planter was operating in the field, different soil moisture content would lead to different degrees of soil subsidence and deformation. The subsidence and deformation of the soil will directly affect the flatness of the soil, thereby affecting the working quality of the seeding machinery [13-14]. Therefore, the influence of different types of soil moisture content on the corn sowing monitoring system was studied, and the system structure was improved. It can improve the monitoring accuracy of the seeding operation quality of the seeder in different types of fields, and is more conducive to the large-scale promotion of the no-tillage seeder.

2. Experimental Procedure

2.1 Determination of moisture content of different types of soil

As shown in Figure 1, three different types of experimental cultivated land (corn cultivated land, wheat cultivated land and plowed cultivated land) were selected in Mengjin County, Luoyang City. The slope of the three experimental cultivated land was 2° ~ 5°. The moisture content of the three types of soil samples was measured by the drying method [15]. Firstly, the soil samples of three cultivated lands respectively were taken with the soil drill, sealed with the aluminum box and take them back to the laboratory. The moisture of the soil samples were measured with an electronic balance with an accuracy of 0.1g, then the soil samples were placed in a drying cabinet and dried at a temperature of 105° for 10 h to constant weight, and measured the mass of the soil samples after drying. Then the moisture content of three types of soil samples was obtained according to the calculation method, and six groups of three types of soil samples were measured respectively.

Fig. 1: Soil drying process

$$P_w = \frac{m_b - m_{bt}}{m_a - m_{at}} \cdot 100\% \tag{1}$$

where, P_w is Soil moisture content, m_b is total amount of containers and soil samples before drying, m_{bt} is total weight of containers and soil samples before drying, m_a is total amount of containers and soil samples after drying, m_{at} is total weight of containers and soil samples after drying. The moisture content of three soil samples is shown in Table 1.

Table 1

Camera parameters of the inspection system

Number of groups	Moisture content of corn no -tillage land (%)	Moisture content of wheat no -tillage land (%)	Moisture content of cultivated land (%)
1	34.6	26.7	23.7
2	35.8	28.1	23.1
3	32.4	27.2	25.3
4	33.7	27.3	24.2
5	36.8	26.6	23.5
6	30.5	28.5	23.3
average value	33.97	27.40	23.85

2.2 Seeding quality monitoring system

As shown in Figure 2, the quality information about seeding operation is mainly collected by photoelectric sensor and laser sensor. Photoelectric sensor and laser sensor are mainly used for seeding monitoring and seeding depth monitoring respectively

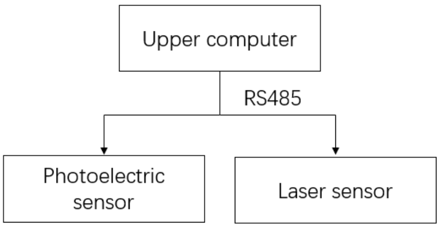

Fig. 2: Schematic diagram of planter operation quality monitoring system

2.3 2bj-470 planter structure

2bj-470 finger clip type corn no-tillage precision seeder is mainly composed of traction frame, driving ground wheel assembly and sowing monomer assembly, as shown in Figure 3. The driving ground wheel assembly comprises a walking ground wheel and a sowing driving ground wheel; The sowing unit comprises a frame, a fertilizing and ditching device, a grass divider assembly, a rower, a profiling four-bar frame, a seed box and a seed metering device assembly. During the operation of the seeder, the metal ground wheel on the seeder transmits the power to the sprocket on the hexagonal shaft of the transmission frame through the chain. The sprocket on the hexagonal shaft transmits the power to the sprocket on the fertilizer discharger and the fertilizer discharge shaft, which drives the fertilizer discharger to discharge fertilizer. The sprocket on the downward seeding unit on the hexagonal shaft drives the seed metering device for seeding, the fertilization opener opens the trench and fertilizes, and the grass divider clears a clean seedling belt. The seeding unit mechanism of the seeder separately performs the whole process of ditching, planting, covering and suppressing, and completing the precision seeding of no-tillage and fertilization of corn.

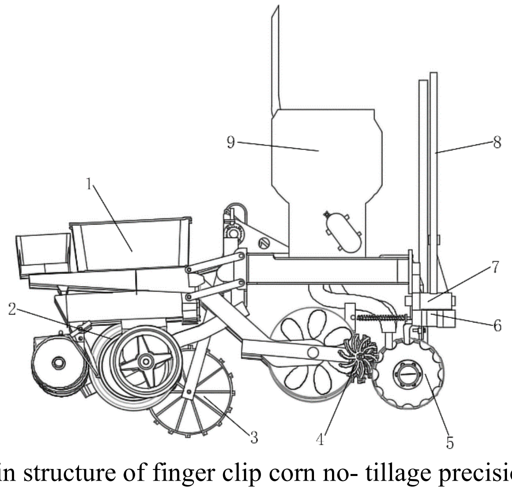

Fig. 3: Main structure of finger clip corn no- tillage precision planter
1. Seeding unit; 2. Transport wheel; 3. Sowing driving wheel; 4. Grass divider assembly; 5. Fertilizer opener; 6. Rack; 7. Traction ring; 8. Rower; 9. Fertilizer box

2.4 Broadcast monitoring module

The sowing quantity monitoring module adopts through-beam photoelectric sensor, which mainly monitors the sowing quantity, missed sowing, replaying and single-grain rate and other sowing information in the working process [16]. During the working process of the sensor, the receiving end will not receive the beam due to the uneven surface of the corn kernels, and the sensor is installed relative to each other to avoid the angle of the transmitting end being affected by the vibration during the working process of the seeder, which can improve the monitoring accuracy.

As shown in Figure 4, the sensor uses adopts three infrared emitting diodes and a photodiode placed in parallel as the transmitting end and receiving end respectively. The irradiation angle of the three infrared emitting diodes can reach 360 °, so as to fully cover the seed metering tube, eliminate the monitoring blind area and improve the monitoring accuracy.

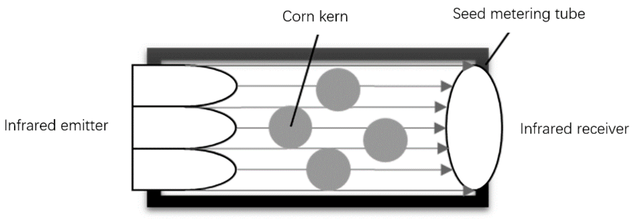

Fig. 4: Photoelectric sensor no blind area monitoring

As shown in Figure 5, the vibration frequency of the seed metering tube is obviously less than that of the seed metering device during the working process of the planter. The photoelectric sensor is installed on the seed metering tube to reduce the impact on the vibration frequency of the information collection of the photoelectric sensor.

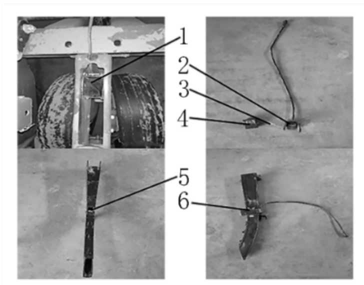

Fig. 5: Installation position of photoelectric sensor

1. Seed metering tube; 2. Infrared emitter; 3. Power cord; 4. Infrared receiver; 5. Detection starting point; 6.Sensor

2.5 Seeding depth monitoring module

The monitoring of sowing depth is realized by laser sensor. Panasonic hg-c1400 laser sensor is selected, with a measurement range of 200 ~ 500mm and a repetition accuracy of 250 μm which can meet the actual needs. As shown in Figure

6, the steel plate with length of 200mm and width of 180mm is fixed in front of the pressing wheel by screws, the steel plate is folded down from the width of 60mm, and the hg-c1400 laser sensor is fixed on the steel plate by screws to record the sowing depth information during sowing operation and transmit it to the upper computer.

Fig. 6: Main structure of finger clip corn no- tillage precision seeder
1. Seeding unit; 2. Steel plate; 3. Disc ditcher; 4. Hg-c1400 laser sensor; 5. Depth limiting wheel; 6. Data line

2.6 Collection of sowing quality information

The corn seeds selected in the field experiment are Jundan 20, with a mass of 1000 seeds of 308.24g, an average density of 1.12g/cm^3, an average grain size of 11.21 · 8.43 · 4.29 (mm, length · width · height, the average value is taken after measuring 100 seeds), and the seed yield is 89.4%.The test equipment is 2bj-470 finger clip intelligent corn no tillage precision planter, which collects the sowing and sowing depth information during the working process through photoelectric sensor and laser sensor, and transmits the information to the upper computer.

2bj-470 planter is pulled by tractor. According to the local agronomic requirements, the plant spacing is set as 25cm and the row spacing is set as 60cm. Under the condition of that the tractor speed is kept at a constant speed of 6km / h, the sowing quality test on three different types of cultivated land is completed. As shown in Figure 7, the constantly monitoring of sowing operation information is carried out by the upper computer in real time. The collected broadcast volume, broadcast depth and other information will be displayed in the software interface in real time, and the original data will be automatically recorded in the background for later analysis and processing.

Fig. 7**:** Field test of planter

2.7 Collection of sowing quality information

When the 2bj-470 corn no till planter works, the seeds fall from the seed metering device. When the seeds pass through the photoelectric sensor, the sowing quantity is increased by one. The falling time of two adjacent seeds is counted according to the switching value signal. The theoretical plant spacing is compared with the actual plant spacing according to GB / t6973-2005 test methods of single grain (precision) planters, and the following formula is used to judge whether the seeds are replayed or missed.

$$\begin{cases} v\Delta t < 0.5\bar{d}(repeated\ sowing) \\ v\Delta t > 1.5\bar{d}(Missed\ seeding) \end{cases} \quad (2)$$

where, v is the vehicle speed, in m/s; △t is the interval between two adjacent seeds, unit: s; $\bar{d}$is the theoretical plant spacing, inm.

After each seed is judged, the missed seeding rate, replaying rate, number of single seeds and single seed rate are calculated according to the following formula.

$$\begin{cases} n_2 = n - 2n_1 \\ S = \frac{n_2}{n} \times 100\% \\ S_1 = \frac{n_1}{n} \times 100\% \\ S_2 = \frac{n_3}{n} \times 100\% \end{cases} \quad (3)$$

where, n is the total sowing amount; n_1 is the number of replays; n_2 is number of single grain; n_3 is number of missed seeding; S is the single grain rate; S_1 is the replay rate; S_2 is the missed seeding rate.

When the planter is working in the field, the hg-c1400 laser sensor starts to continuously measure the height d_1 from the ground and transmits the measured data to the controller through the V20 analog input port. As shown in Figure 8, since the vertical distance between the hg-c1400 laser sensor and the end of the disc opener is d_2, the sowing depth is

$$d_3 = d_2 - d_1 \quad (4)$$

where, d_1 is the height of the sensor from the ground, in mm; d_2 is the vertical height of the sensor from the end of the trencher, in mm; d_3 is the sowing depth, in mm.

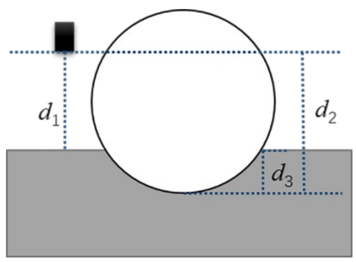

Fig. 8: HG- C1400 laser sensor monitoring principle

3. Results and discussion

3.1 Data analysis of sowing quality

In this experiment, the tractor repeated the experiment three times in corn free cultivated land, Wheat Free cultivated land and rotary cultivated land. Take 200 seeds and put them into the seed hopper, monitor the operation data of the planter at a constant speed for 30s, and resow and miss sow artificially. The sowing monitoring data showed that with the decrease of soil moisture content in the test field, the monitoring accuracy of sowing amount, missed sowing and replay of the planter increased from 97.00%, 96.33% and 92.73% to 98.50%, 98.10% and 98.21% respectively. As shown in Table 2, the results show that the sowing monitoring accuracy of 2bj-470 maize no- tillage planter gradually increases with the decrease of soil moisture content.

Table 2

Sowing monitoring accuracy test data in three fields

Soil type	project	Actual value / piece	Monitor Value / piece	Monitoring accuracy /%	relative error /%
Corn free farmland	Seeding rate	200	194	97.00	3.00
	Missed seeding	105	109	96.33	3.81
	Repeated sowing	110	102	92.73	7.27
Wheat Free farmland	Seeding rate	200	195	97.50	2.50
	Missed seeding	105	102	97.14	2.86
	Repeated sowing	110	103	93.64	6.36
Rotary cultivated land	Seeding rate	200	197	98.50	1.50
	Missed seeding	105	103	98.10	1.90
	Repeated sowing	110	112	98.21	1.82

The set sowing depth of the planter is 50mm. After sowing, randomly select three square areas with length · width of 3 · 2.5m in three fields, excavate the soil on the seeds, measure the actual seed sowing depth, compare it with the sowing depth monitored by the planter, and repeat the test for three times. The test data of sowing depth monitoring accuracy are shown in Table 3.

Table 3

Sowing monitoring accuracy test data in three fields

Soil type	Number of seeds /seed	Actual average sowing depth /mm	Monitoring average sowing depth /mm	Relative error of monitoring average sowing depth /%	Average monitoring accuracy /%
Corn free farmland	49	49.52	53.55	7.53	93.64
	50	47.90	51.02	6.12	
	46	49.62	52.48	5.45	
Wheat Free farmland	47	48.82	52.47	6.96	93.70
	49	50.61	53.72	5.79	
	48	49.14	52.37	6.17	
	50	50.42	52.85	4.60	96.13

Rotary cultivated land	51	50.49	52.21	3.29	
	48	49.13	51.02	3.70	

The test data of sowing depth monitoring accuracy show that the sowing depth monitoring accuracy of planter in rotary tillage land is the highest, reaching 96.13%, while the monitoring accuracy in corn no- tillage land and wheat no- tillage land is 93.64% and 93.70% respectively. It shows that the monitoring accuracy of sowing depth of the planter is the highest in the cultivated land with low soil moisture content. The main reason for this phenomenon is that after the seeds fall from the planter, the surface soil will decline to a certain extent due to the suppression of the depth limiting wheel and V-shaped compactor, while the decline will be more obvious in the field with high soil moisture content, which result in large deviation in sowing depth monitoring.

The experimental results show that the 2BJ-470 seeder's sowing and sowing depth monitoring accuracy can reach more than 92% when operating in three different types of fields. Moreover, the precision of sowing and sowing depth monitoring is the highest in the cultivated land with low soil moisture content, which can reach more than 96%, indicating that when 2bj-470 no tillage planter operates in the cultivated land with low soil moisture content, the precision of sowing operation quality monitoring system is the highest.

4. Conclusion

(1) In this paper, the soil moisture content of corn free cultivated land, wheat free cultivated land and ploughed cultivated land were measured respectively, and the no- tillage sowing operation quality monitoring system was designed to monitor the sowing operation quality of no- tillage planter in different cultivated land soil types.

(2) In this paper, the quality monitoring experiment of sowing operation was carried out. By collecting the sowing and sowing depth and other information monitored by the planter when working on different types of cultivated land, and comparing with the actual information, the following conclusions are drawn: the monitoring accuracy of 2bj-470 planter can reach more than 92% when working on three types of cultivated land. At the same time, the monitoring accuracy of sowing and sowing depth information in cultivated land with low water content is higher than that in corn no- tillage land and wheat no- tillage land with high water content, which is more than 96%.

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