REAL-TIME MISSED SEEDING MONITORING PLANTER BASED ON RING-TYPE CAPACITANCE DETECTION SENSOR
/
基于环形电容检测传感器的实时漏播监测播种机

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ABSTRACT
In order to improve the quality of corn sowing and fertilizer utilization, reduce labor costs, this paper aimed at the traditional tillage fertilizer machine to improve. The seeding and fertilizing machine with adjustable flow is designed by integrating particle fertilizer sensor and CAN bus transmission technology. It is mainly composed of seed and fertilizer discharging mechanism, ditch and soil covering mechanism, and leakage seeding and blockage monitoring system. Fertilizer drop signal can be obtained in real time by detecting the flow sensor outside the fertilizer discharge pipe. The speed of the stepper motor can be adjusted after signal processing, which can also realize the alarm of missing sowing and blocking light, and realize the precise variable sowing. The field experiment results show that the maximum relative error of seed leakage rate monitoring is 3.75%, and the alarm accuracy of fertilizer clogging is high. This machine can reduce the intensity of manual operation, and the quality of operation can be effectively monitored and controlled, can effectively reduce the production cost, has better practicability and economy.

摘要
为了提高玉米播种质量和肥料利用率，降低劳动成本，本文针对传统耕作施肥机进行改进。集成颗粒肥料传感器、CAN 总线传输等技术设计的流量可调的播种施肥机，主要由排种排肥机构、开沟覆土机构，漏播堵塞监测系统等组成。通过检测排肥管外的流量传感器可实时获取肥料下落信号。经信号处理后调节步进电机转速，还可实现漏播、堵塞灯光报警，实现精准变量播种。田间试验结果表明：该机种子漏播率监测相对误差最大为 3.75％，肥料堵塞报警准确率高。该作业机械能够减少人工作业强度，并对作业质量进行有效监测与控制，能有效降低生产成本，具有较好的实用性和经济性。

INTRODUCTION
As a big agricultural country, the development of agriculture occupies a pivotal position in China *(Jin et al., 2019)*. Sowing and fertilizing is one of the most important works in agricultural activities, which plays an important role in ensuring grain production and increasing agricultural output. However, the phenomenon of excessive and partial fertilizer application in agricultural production is widespread *(Jin et al., 2018)*. This causes a huge waste of resources and threatens the ecological environment. Sowing in most areas still depends on manpower. With the development of intelligent agriculture, variable seeding and fertilizer applicator also advances by leaps and leaps. Variable fertilization seeding technology is an important part of precision agriculture. It is based on the actual needs of crops, scientific fertilization methods and rational seed distribution *(Zhou et al., 2017)*. Computer is used to guide fertilization and seeding operations and to determine the variable input of crop growth requirements. Reasonable reduction of resource input can not only improve the natural ecological environment, but also achieve higher economic benefits *(Zhou et al., 2014)*.

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Foreign agricultural machinery and equipment have experienced more than 100 years of development, has been relatively mature at present, the main representative countries being Japan, Western Europe, the United States and other developed countries. At present, the foreign mainstream seeding machinery has been able to integrate land preparation, seeding, fertilization, watering, filling, suppression and other functions as one, reducing repeated labor, reducing the waste of human resources, to achieve the protection of the land *(Bai et al., 2020)*. A typical example is: German company AMA - ZONE developed a variable fertilizer application machine based on vision sensor. Through the sensor installed in the front end of the machine, the nutrient deficiency of the crop can be measured, and the amount of fertilizer top dressing can be calculated. After signal processing, the hydraulic motor is finally controlled to realize variable fertilization *(Xiong et al., 2020)*. The JD-1820 pneumatic variable fertilizing planter developed by John Deere is equipped with sowing quality monitors, star sensors, hydraulic motor drive controller monitors and other transmission and signal processing equipment. It can realize variable regulation of fertilizer application by controlling the opening of hydraulic proportional valve *(Jin et al., 2018)*. Case developed variable seeding and fertilizer applicator using digital image processing technology. During the operation, the high-speed camera was used to take the pictures of the seeding outlet at the natural frequency, and the seed out state parameters of the seeder were obtained by combining with the digital image processing technology. Then, the curve of seed motion trajectory was drawn according to the mathematical model. According to the curve, the scattered distribution state of seeds can be known, and the dynamic adjustment can be made to adjust the size of the sowing amount in real time.

In contrast, China's agricultural machinery started late and the industrial foundation is weak, so the technology is relatively backward *(Chen, 2017)*. The autonomous on-demand fertilization device, developed by Jilin University, uses IC cards, GPS and other devices only. The principle is to divide the field into grids of equal area, and the microcontroller identifies the cells to read the corresponding amount of work. The variable fertilization can be realized by adjusting the size of the opening degree of the chute wheel and changing the amount of work by adjusting the rotational speed of the chute wheel *(Jia, 2016)*. Shanghai Agricultural Machinery Research Institute and Shanghai Jiao Tong University jointly use the global positioning system GPS to design a multi-functional variable feeding machine, which is the first intelligent variable feeding machine based on GPS independently developed in China. The machine has two schemes of motor drive and hydraulic drive, as well as a variety of variable fertilization prescription generation mode, which can realize the touch screen display and modification of operation information *(Zhang, 2013)*.

On the basis of the existing research, the main seeding object of this paper is corn crop. It CAN deal with different demands for cultivation in different regions. It integrates technologies such as vehicle sensors, CAN bus transmission and PC terminal, aiming to realize seed fertilizer monitoring and variable fertilization under the condition of simultaneous sowing of corn seed fertilizer.

MATERIAL AND METHODS

OVERALL STRUCTURE DESIGN OF FERTILIZER APPLICATOR

2.1 Structural design, principle and main technical parameters

2.1.1 Structure design and working principle

The main structure of this machine includes the fertilizer box, fertilizer device, transmission bearing, controller, soil covering device, suppression wheel, rotating chain, suppression spring, seed discharging box, etc. The whole machine adopts the symmetrical structure design, in the advance process of the unit fertilizing first, and then sowing. The seed fertilizer box is installed on the upper part of the front end of the frame, and four internal groove wheel fertilizer drains are installed on the lower part. The fertilizer drains are connected to the front row furrow opener which can open deep trenches through the fertilizer drains pipe, and the furrow opener is fixed to the beam at the front end of the frame through the bolt connection. The seed box is arranged above the rear end of the frame, and the seed metering device at the bottom is connected to the frame through the L-shaped steel plate. The seed metering device is connected with the rear row-type trencher through the seed metering device pipe, and the seed trencher is also equipped with a parallelogram copying mechanism. The intermediate power transmission shaft is fixed to the rear of the frame by steel plates. The wheels are connected to the intermediate shaft through the H plate. One end of the compression spring is connected to the box frame by rotation, and the other side is connected to the H on the panel by rotation. In addition, there is a shaft in the middle of the spring to prevent the spring from moving in other directions.

Before the operation of the fertilizer applicator, the relevant parameters of the operation of the machine should be calibrated first, and then input into the database of the circuit control module. Then, the information of the fertilizer quantity of the section that needs fertilizer is also input into the circuit control module. The fertilizer applicator is driven by a diesel engine. There is a stepper motor at the outer end of the fertilizer spreader groove wheel to monitor the movement speed of the fertilizer spreader in real time. The speed information is transmitted to the circuit controller, and the circuit controller analyzes the data, calculates the rotation pulse frequency of the stepper motor and transmits it to the driver. The driver drives the stepper motor to rotate, so as to achieve the purpose of controlling the rotation speed of the transmission shaft. The fertilizer applicator applies a quantitative amount of chemical fertilizer deep into the fertilizer ditch directly below to complete quantitative and accurate fertilization.

2.1.2 Main technical parameters

The connection mode between the machine and the tractor is traction type, and its main technical parameters are shown in Table 1.

Table 1

Main technical parameters

Design content	Unit	Parameter
Auxiliary tractor	The bumper harvest - 180 type wheel tractor	18 (13.2 KW/ps)
Power disc diameter × rotation speed	(mm x r/min)	400 x 50
Spacing × number of rows	(cm x line)	60 x 4
Planting distance	(cm x strain)	20
Sowing depth	(cm)	2.5 ~ 5
Fertilization depth	(cm)	5 ~ 6
Operating speed	(km (h)	4 ~ 8
Machine weight	(kg)	**320**

2.2 Fertilization device design

2.2.1 Distribution

The existing fertilizer discharging methods of variable fertilizer applicator mainly include external centrifugal type, groove wheel type and spiral type *(Shi et al., 2017)*. Most of the domestic fertilizers discharging devices choose external groove wheel type. The outer groove wheel fertilizer discharge device is usually composed of a fertilizer discharge box, an outer groove wheel, a brush, a retaining ring etc., the seeding and fertilizing machine is mainly used for discharging granular urea, granular compound fertilizer and farm self-made granular fertilizer and other chemical fertilizers. The main technical characteristics of chemical fertilizers are shown in table 2.

Table 2

Main technical indexes of commonly used fertilizers

Type of fertilizer	Shape	Moisture content (%)	Mass per unit volume (g/L)	Natural angle of repose (°)
The urea	particles		720	35
Ammonium sulfate	granular	0.93	943	44
Ammonium nitrate	crystalline	2.13	1010	35
Ammonium bicarbonate	powder	2.87	920	37
Ammonium phosphate	crystals	2	840	
Calcium superphosphate	powder and granular	16	880	

Corn is seeded with chemical fertilizers such as compound or urea, which have similar physical properties and are granular and have a low water content. Therefore, in this design, the external groove wheel fertilizer discharge device is selected. As shown in Fig. 1, the advantages of the fertilizer discharge device are outstanding, with better stability and uniformity of fertilizer discharge, and there can be a more precise control of the displacement *(Zhang and Zhang, 2011)*.

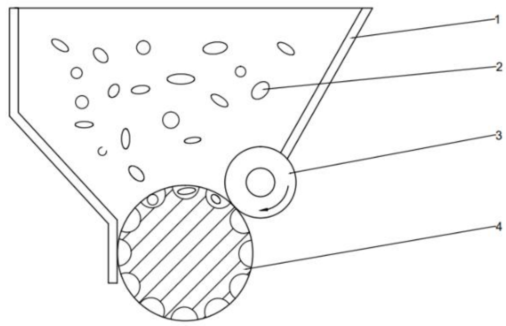
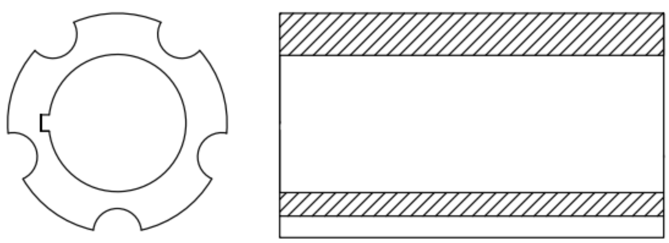


Fig. 1 - Structural schematic diagram of outer groove wheel seed platter

1. Seed box; 2. Seed; 3. Scraping wheel; 4. Placing wheel

When the fertilization device works, the chemical fertilizer in the fertilizer box enters the fertilizer discharge device from the fertilizer box under the action of gravity and fills the grooves of the groove wheel. The fertilizer discharging shaft drives the grooves to rotate, and the fertilizer in the grooves of the grooves is rotated by the grooves to force down, and finally is applied into the grooves opened by the trencher below.

The groove wheel is a key part of the process, accurately measuring the fertilizer and allowing it to flow into the manure ditch (Figure 2). The size of groove wheel determines the precision of fertilization and discharge effect, thus affecting the performance of the whole machine, so the size of groove is very important.



(a) Main view (b) Left view

Fig. 2 - Two-dimensional structure of groove wheel

The relationship between the displacement and the number of turns of the grooved wheel can be as follows:

$$Q_1 = 5bQ \tag{1}$$

Where$Q_1$is the displacement of a fertilizer discharge device within 50m length, g; b is for calculating line spacing, m; Q is the amount of fertilizer discharged, kg/hm^2;

b= 0.6; Q=450 is substituted into Equation (1), and then: Q_1=1350 g

Number of turns of grooved wheel 50m forward:

$$N = \frac{Q_1}{q} \tag{2}$$

In the formula, $N$is the number of turns of the wheel shaft, integer; Q_1 is the displacement, g; q is the displacement of one turn of the fertilizer shaft, under the specified working length of the groove wheel.

Known: Q_1=1350 g

At that time a_0=0.8; L=1.5; λ=0.17;$q_1 = 49.0376\ g/r$ N=27

When a_0=0.17; L=3.0; λ=0.19;$q_1 = 100.63704\ g/r$ N=14

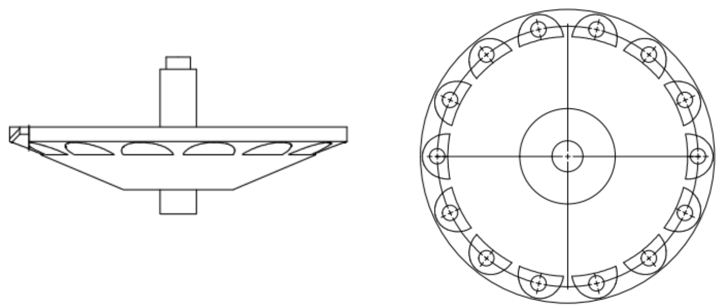
When a_0=0.19; L=6.0; λ=0.20;$q_1 = 202.8523\ g/r$ N=7

Grams/radius（g/r）is the mass of fertilizer discharged after one turn of the grooved wheel.

As can be seen from the above relation, when the external groove wheel fertilizer discharge device works, if the diameter is too large, the speed will decrease accordingly. If the diameter is too small, it will affect the discharge of fertilizer, or destroy fertilizer particles. According to the manual, determine the working length of the groove wheel of 40mm, the groove radius r=8 mm, and the groove number z=10.The length, size and position of the seed platter grooves and the speed of the distribution axis are the main influencing factors of the distribution working performance and a main evaluation index of stability. Through verification, it is concluded that the effective length of the outer grooved wheel is 60mm, the speed of the rotating shaft is 35-70 r/min, and the fertilizer discharge is relatively stable.

2.2.2 Metering plate

Seed platter is the key part of precision fertilization planter. The rationality of the structure designed according to the corresponding working principle directly determines the working performance of the whole machine. At present, the main mechanical seed planter is mainly under the action of gravity, relying on the structure to achieve seed filling and seed planter. The quality of the seed plate determines the quality of the seed.



(a) Main view (b) Top view

Fig. 3 - Structure of inclined disc type row dial

The inclined disc seed platter requires that the seeds be treated before sowing, to pelletize the seeds, which enables different seeds to have similar physical properties. In the design of seed platter, the differences of seeds can be approximately ignored to obtain approximately stable seed flow, making the plant spacing more accurate. In this project, the inclined disc is used as the seeding mechanism as shown in Figure 3.The inclined disc design can make full use of the gravity of the seed itself to turn over the seeds to prevent too many seeds from entering a single mold control at the same time and causing the mold control to be blocked, and the inclined setting is also more conducive to cleaning out the seeds that have not been completely discharged from the seed platter.

2.2.3 Seeding opener

The function of the trencher in the design of the fertilizer seeder is to open the trenches before planting. The effect of trencher can indirectly determine the depth of seed row, so that the seeds can reach the predetermined depth, and then improve their survival rate.

The ditching parts shall meet the following requirements:

(1) After the furrow opener work, the shape of the ridge should be kept regular.

(2) Ditch opener should meet different agronomic requirements. For example, operation can be carried out under different row spacing.

(3) After opening the ditch, the bottom of the ditch is left with an appropriate amount of loose soil to facilitate the germination of seeds.

(4) The designed components should meet the characteristics of small working resistance and stable operation.

In the process of sowing in the field, the machine will affect the sowing effect due to the uneven field, so that the seeds cannot reach the predetermined depth. The copying mechanism can change with the change of terrain under the control of the limiting mechanism, and the seed ditch with a fixed depth can be changed within a certain range, so that the seed can have a fixed sowing depth in different operation requirements.

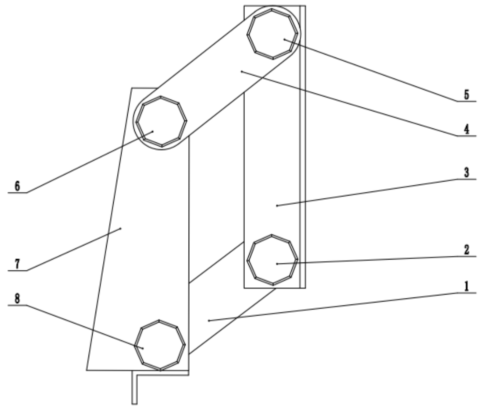


Fig. 4 - Profile mechanism

1, 4 pull rod; 2, 5, 6, 8 connecting pin; 3 mounting frame

Figure 4 shows the single profiling mechanism of the planter. This design adopts a single copying mechanism with slightly better copying effect. It can be known that the size of four connecting rods, traction angle, stiffness and strength of the mechanism will affect the effect of profiling *(Huang et al., 2014)*. The change of terrain will cause the change of support reaction force. In order to ensure the consistent sowing depth, pressure or tension spring should be added to make the copying mechanism always maintain the appropriate pressure on the ground.

Through comprehensive analysis of various data, it can be found that the average furrow depth obtained by using different forward speed and furrow opener is significantly different. Increasing the forward speed will affect the performance of the trencher and lead to an increase in the depth variation coefficient *(Tachibana et al., 2014)*. When the current feeding rate is 1.0 m/s, the actual average fertilization depth is approximated to the rated fertilization depth. The most uniform depth of the fertilizer can be obtained by using a hoe trencher at a forward speed of 1.2 m/s *(Tachibana et al., 2014)*. Therefore, we set the speed of the machine to be about 1.0-1.2 m/s.

2.3 Circuit control module

The online detection system of fertilizer application is mainly composed of capacitive fertilizer flow sensor, forward speed sensor and on-board terminal, as shown in Fig. 5.

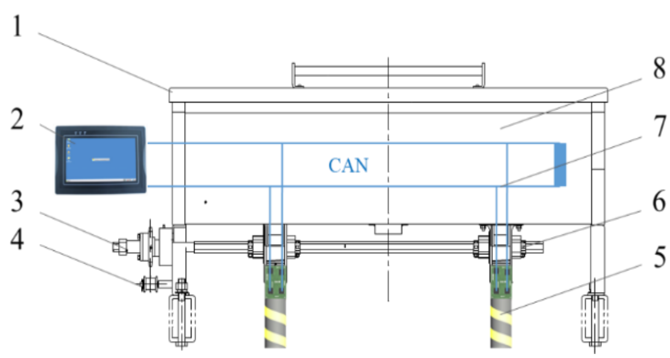


Fig.5- Schematic diagram of application rate detection system structure

1. Rack; 2. On-board display terminal; 3. Drive shaft; 4. Speed sensor; 5.Flow sensor;
6. Fertilizer discharge device; 7.CAN bus; 8. Fertilizer box

The system adopts CAN bus structure, which can realize distribution online detection of each fertilization pipeline and facilitate node expansion of fertilizer applicator with different width (*Marin et al., 2014*). The capacitive fertilizer flow sensor is installed on the fertilizer discharge pipe, which is mainly used to obtain the online mass flow of fertilizer. The forward speed sensor is located on the forward ground wheel, which is mainly used to obtain the forward speed of the machine and tools. The on-board terminal is located in the cab, which receives real-time information through the built-in CAN bus adaptation module, and displays the fertilizer application amount after processing the information (*Gângu et al., 2008*). In addition, the fertilizer flow sensor can judge the blocked state of the pipeline according to the state of fertilizer in the fertilizer pipe and display the alarm state through the alarm indicator light on the sensor.

2.3.1 Detection principle

When the fertilizer applicator operates normally, the fertilizer falls freely in the closed tube. The capacitive sensor is installed on the pipe wall. When fertilizer falls through the capacitor plate, the equivalent dielectric constant changes, causing the change of output capacitance parameters.

$$\Delta C = C - C_0 = \frac{s(\varepsilon_1 - \varepsilon_2)}{\rho_1 dV} m_1 \quad (3)$$

Where ΔC is the fertilizer through sensor capacitance variation, F; s is the plate area, m^2; ε_1 is the dielectric constant of fertilizer, F/m; ε_2 is the dielectric constant of air, F/m; ρ_1 is the density of fertilizer, kg/m^3; d is the plate spacing, m; V is the detection field volume between capacitance sensor plates, m^3; m_1 is the fertilizer quality in the sensor, kg.

It can be seen from Equation (3) that there is a linear relationship between the change of the output capacitance of the sensor and the quality of fertilizer in the testing site. Therefore, the on-line measurement of fertilizer mass flow rate can be realized by acquiring capacitance signal in real time. In addition, when the fertilizer pipe is blocked, the fertilizer in the sensor detection field will accumulate rapidly, the fertilizer quality will increase significantly, and the output capacitance of the sensor will increase sharply, so as to realize the monitoring and alarm of the obstruction fault of the fertilizer discharge pipeline.

2.3.2 Sensor detection circuit

Considering the influence of the detection accuracy, reliability and package size of the micro capacitor, the conditioning circuit of the fertilizer flow sensor was designed by using the capacitance digital conversion method. The capacitance digital conversion chip AD7746 and microcontroller STM32F103C8T6 were used to construct the micro capacitor signal measurement circuit (*Cay et al., 2018*).

MCU STM32F103C8T6, as the master control unit of the measuring node, is integrated with IIC and CAN transceiver module. It mainly completes the system configuration and initialization of the node, capacitance signal reading, preprocessing, alarm drive and data communication, etc. Among them, the microcontroller through the IIC interface and AD7746 data communication, in the completion of the AD7746 parameter setting, can read the converted capacitance information, and the signal pretreatment.

The AD7746 is a 24-bit capacitive digital converter with an operating voltage range of 2.7 to 5.25V.AD7746 internally mainly includes: modulator, voltage reference, excitation voltage source, digital/capacitor converter (CAPDAC), temperature sensor, digital filter, I2C bus interface. It includes two capacitive input channels that can be configured for single-ended input and differential input modes. Through the I2C interface, the configuration of AD7745 internal registers and the reading of internal conversion results can be realized. The AD7745 has a resolution of 4AF, an accuracy of 4FF, and a range of ±4pF.By setting the CAPDAC register with a range of 0~17pF, the range can be changed to CAPDAC±4pF with a sampling speed of 10~90Hz.The AD7745 can be directly connected to the capacitance sensor through a short wire to complete the capacitance measurement.

The sensor uses CAN bus for data interaction, and STM32F103C8T6 built-in CAN bus controller realizes the receiving and sending of CAN information through SN65HVD230 transceiver.SN65HVD230 is compatible with 3.3V voltage and its communication rate can reach 1M/s, which can meet the actual needs.

2.3.3 Signal acquisition and processing

The on-board terminal is the key part of the application amount detection system software operation. It receives the information of fertilizer flow rate and forward speed in real time, and calculates and processes the information. The terminal adopts the Atom motherboard based on X86 architecture as the core, integrates solid-state storage module, data communication module, liquid crystal display and input/output module, and obtains data on the bus in real time through the built-in USB-CAN communication adapter module.

Using Keil software development environment, the software of the lower microcontroller is written in C language. The software design adopts the modular programming method, and its functions mainly include system initialization, PCAP01 firmware writing CAN module initialization, capacitance data acquisition and preprocessing.

After the system is power-on, the SCM executes the initialization program to complete the configuration of each IO port, and then reads the firmware information of the internal EEPROM, and writes the SRAM area inside the PCAP01 through the SPI bus to enter the configuration state of PCAP01, where the sampling rate is configured at 10kHz and the blocking alarm threshold is 0.5pF.When the capacitance measurement is completed, the SCM reads the measurement result of PCAP01 and gets the capacitance information. On the one hand, the data is sent to the on-board terminal through CAN bus, and at the same time, the real-time capacitance is compared with the blocking threshold. Once the blocking threshold is exceeded, the SCM drives the corresponding IO port to make the alarm indicator light constantly on to realize the alarm.

RESULTS AND DISCUSSION

In order to test the accuracy of the fertilizer application rate detection system under the conditions of different fertilizer discharging speed, experiments were carried out in Shengfa Family Farm, Duanpolan Town, Qingdao City from September 18 to 20, 2020.Compound fertilizer, N-P_2O_5-K_2O, was used as experimental fertilizer ratio 24-14-9. Fertilizer particles are uniform without caking.

3.1 Experimental results of pipeline blocking alarm

A feeding box is placed at the fertilizer outlet of the measuring device, and the weighing method is adopted to calibrate the sensor. The rotation speed of fertilizer discharge shaft was set as 20r/min, and the rotation time of fertilizer discharge shaft was controlled by the upper computer respectively, and the difference of fertilizer discharge quality was realized according to the difference of running time. After each fertilizer discharge, an electronic balance (SL4001, Shanghai Minqiao Electronic Instrument Factory, 4000±0.1g) was used to measure the fertilizer quality in the receiving container, and at the same time, the cumulative capacitance value of the difference between the capacitance sensor and the reference capacitance sensor for each test was recorded. One calibration test was carried out for each fertilizer. Matlab software was used to process the calibration test data, and the response curve of fertilizer quality and capacitance value was obtained.

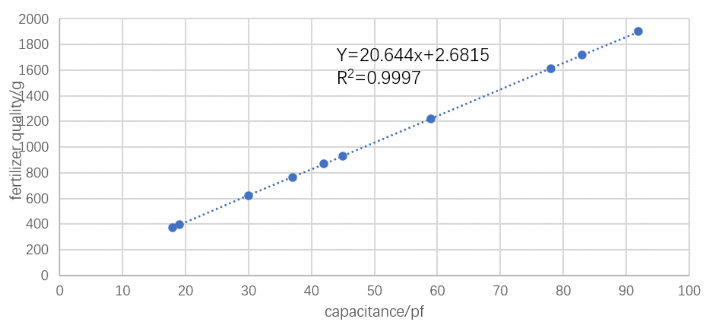


Fig. 6- Relation curve between capacitance sensor output and fertilizer quality

Figure 6 shows the signal response of the composite fertilizer after it passes through the improved sensor. As can be seen from the figure, when the fertilizer passes through the sensor, its capacitance value will change significantly, increasing from 8.75pF to 8.87pF.

The relationship model between capacitance and mass was obtained by linear fitting and normalization of the test data:

$$Q(t) = 20.644C(t) + 2.6815 \tag{4}$$

It can be seen that the capacitance output value of the granular fertilizer flow sensor has a linear relationship with the fertilizer quality. As the fertilizer quality increases, the capacitance output increases correspondingly. The determination coefficient of the model R^2=0.9997.

3.2 Analysis of fertilization effect results

During the experiment, the rotation speed of fertilizer discharge shaft was set between 25r/min and 35r/min, and fertilizers at the discharge hole were collected at the same time. The measured value of fertilizer application obtained by the detection system was compared with the actual weighing value of collected fertilizers, and the measured value was compared with the actual value. The results were shown in Table 3.

Table 3

Test results of fertilizer application rate detection system

Speed of fertilizer discharge shaft Rotation rate/ r/min	Measured value of fertilizer Measuringmass / g	Real quality Realmass /g	Error Relative error/ %
15	849.2919	864	1.70
	857.756	857	0.09
	345.5783	333	3.78
	643.2648	642	0.20
21	766.0966	776	1.28
	949.4153	961	1.21
	1424.021	1417	0.50
	1799.742	1786	0.77
27	1232.238	1231	0.10
	328.2374	327	0.38
	906.4758	913	0.71
	1919.064	1928	0.46
31	663.4959	650	2.08
	1223.774	1201	1.90
	2191.152	2157	1.58
	1901.723	1875	1.43

As can be seen from Table 3, the system can accurately measure the fertilizer application rate under the conditions of different fertilizer discharging speed, and the average measurement error is 1.13%, meeting the actual requirements.

CONCLUSIONS

1) The particle fertilizer detection technology for planters is proposed, which combines sensors and CAN bus. The planter is mainly composed of monitoring systems for seed metering, ditching and fertilizing, missed seeding, and leaking plugging by various institutions. It can realize four-row seeding operation at a speed of 8 km/h for continuous seeding and fertilization. It can complete the automatic monitoring of sowing and fertilization, and will send out an alarm to remind the staff when it is blocked.

2) This paper proposes a differential capacitive fertilizer flow sensor based on a ring pipe, and builds a micro-capacitance detection circuit composed of STM32F103C8T6 and PCAP01. The Fertilizer Application Rate Detection System based on Lab Windows/CVI was built to realize the on-line detection of fertilizer application.

3) According to the field test results, the maximum relative error of the missing seed rate is 3.75%. The accuracy of the fertilizer blockage alarm is reliable. Using this system can effectively monitor and control the quality of operations and reduce production costs.

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