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Supporting Seeder and Planting Technology for Spring Corn in Arid Areas

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Abstract The annual rainfall is low and the fresh water resources are scarce for the rainfed farming in dry zone of northern China, which seriously affects the sowing and growth of spring corn. In order to solve this problem, the technology of ridge-mulching and side-sowing of spring corn is put forward, the supporting compound operation seeder is developed, and the effect of different speed on the quality of sowing is tested and analyzed. Under the test conditions described in this paper, the seeding operation with a high speed (up to 6 km/h) can be realized, and the quality of the seeding operation can meet the requirements of the national standards. The application of this machine can solve the problem of "drought damage at the booting stage" for spring corn, thereby realizing the deep fusion of farming machine and agronomy in dry farming of northern China, and achieving the integration of farming machine and agronomy.

Key words Dry farming, Spring corn, Seeder, Combined operation, Integration of farming machine and agronomy

1 Introduction

The area of middle and low yielding fields is about 2 666.67 khm^2 in the low plain area circum-Bohai Sea, most of which are dryland, widely distributed in Xingtai, Hengshui, Cangzhou of Hebei Province in the lower reaches of Heilonggang Basin as well as southern Tianjin and northern Shandong. The region is short of fresh water resources, it has saline-alkali barren soil, and the drought problem is serious. The average annual precipitation in this area is about 500 mm, and the precipitation in spring is rare and mostly ineffective. In view of the problem of low planting density and group easy close canopy of spring corn and drought damage at the booting stage in the region, the project team of "Bohai Granary" in Hebei province has developed the technology of "ridge-mulching and side-sowing of spring corn"[1]. According to the agronomic requirements in the technical specification, the 2BYLM-4 spring corn rotary tillage and film mulching seeder has been studied and designed.

2 The technology of ridge-mulching and side-sowing of spring corn

The technology is a new technology for increasing yield of spring corn, which is developed according to the climate and rainfall characteristics in arid area. At the end of spring and the beginning of summer in the arid area, there is little rain, and the precipitation is scarce, and it is the critical period when the spikes of spring corn differentiate and water and fertilizer are urgently needed, so it is prone to drought damage at the booting stage of spring corn. The technology of ridge-mulching and side-sowing by rotary tillage has completely solved this problem. The 70 - 40 - 70 cm wide and narrow row interlaced planting method is adopted in this technology. The broad row is ridged and it is covered with plastic film on the ridge, and the corn seeds are seeded on the ridge side (Fig. 1). This technology has the following advantages:

2.1 The good effect of collecting rain and preserving moisture The ridge is higher than the side furrow, and a small amount of rain water can flow along the film into the furrow where the corn is planted on both sides and accumulated in the soil. After being collected, the rainfall during the growth period can be fully absorbed[3], and the ineffective rainfall can be transformed into effective rainfall. At the same time, mulching also reduces more than 60% of soil moisture transpiration, and the effect of rain collection and moisture preservation is obvious.

2.2 Close planting to increase yield and resist lodging Wide and narrow row planting can increase the ventilation and light transmittance of corn field, enhance photosynthesis and facilitate field management at the same time[4]. As the soil on the side of ridge is piled up during ridging, the soil is not dense, and if the seeds are sown on the ridge side, it is easy to make the growth of corn plant unstable, and it is prone to lodging when there are storms. Therefore, in order to improve the density on ridge side, two plants are seeded in one hole in the study, so that the two plants grow together and the ability of lodging resistance is improved. At the same time, it also increases the number of plants, and the density can reach more than 90 000 plants/ha, which exceeds the conventional density of plants in dry farming area[5], and solves the contradiction between dense planting to increase yield and field management of ventilation and light transmission.

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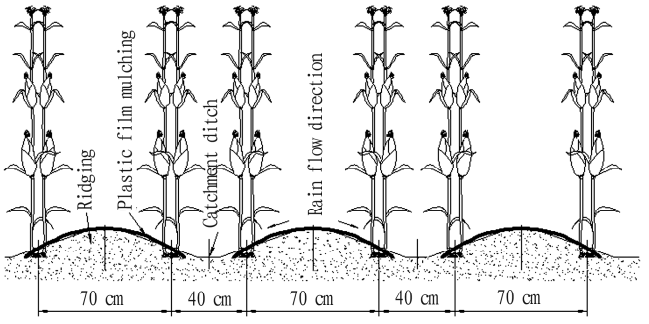


Fig. 1 Cross section of corn sowing

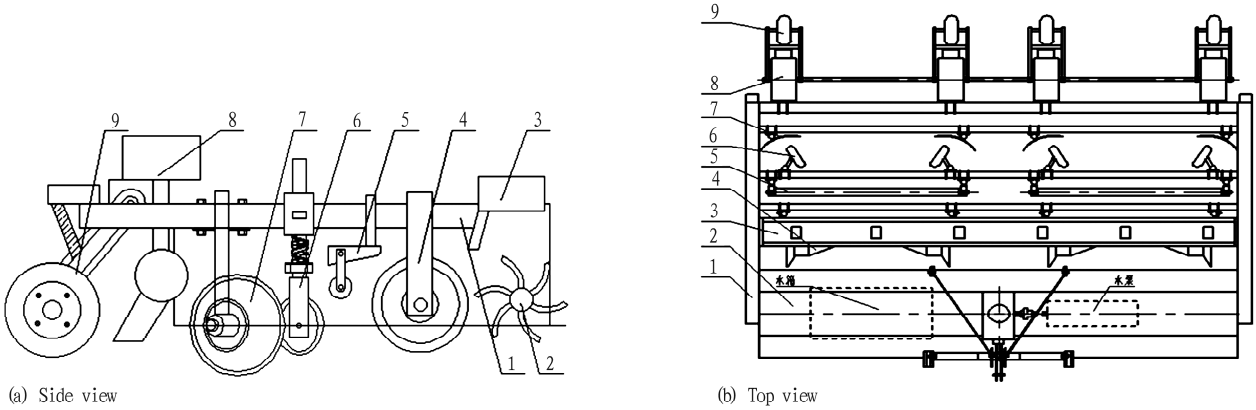
3 2BYLM-4 rotary tillage and plastic film mulching seeder for spring corn The machine adopts the complex joint operation mode, and has six functions, including rotary tillage, fertilization, ridging, plastic film mulching, sowing and compacting, which realizes the complex joint operation of rotary tillage and fertilization, ridging and mulching, double-plant sowing and compaction after sowing. On the basis of mechanization of corn production, a kind of dryland seeder is developed, which combines agricultural machinery with agronomy and realizes the integration of machine and technology.

3.1 The machine structure and parameters

3.1.1 The machine structure. In the design process of 2BYLM-4 rotary tillage and plastic film mulching seeder for spring corn, the following requirements are put forward: ridging type should be raised about 12cm, and ridging side should be compacted; two plants in one hole are required for sowing on the ridge side, and the distance between the two plants is equal to or less than 3 cm. Repressed monomers can float profiling, and the compaction should be suitable for high-speed operation, and according to the spring climate in Heilonggang area, it is required to be able to carry out mulching and sowing when the wind speed reaches level 4.

The structure of 2BYLM-4 rotary tillage and plastic film mulching seeder for spring corn is shown in Fig. 2 after the test and improvement on three generations of sample machines.

The main working parts of the machine, rotary tillage mechanism, ridging mechanism, plastic film mulching mechanism, film-pressing mechanism and disk plow soil-covering device, are installed in the lower part of the frame one after one. The seeder and compaction roller are installed in the rear of the frame. The fertilizer box is installed in the upper part of the front of the frame.



Note: 1. Frame; 2. rotary tillage mechanism; 3. fertilization mechanism; 4. ridge opener; 5. plastic film mulching mechanism; 6. film-pressing mechanism; 7. disc plow soil-covering device; 8. seed box; 9. compaction roller.

Fig. 2 Structure diagram of the seeder

3.1.2 The machine parameters. Repressed monomers can float profiling, and the compaction should be suitable for high-speed operation, and according to the spring climate in Heilonggang area, it is required to be able to carry out mulching and sowing when the wind speed reaches level 4.

3.2 Machine test

3.2.1 Materials and methods. Test materials are shown in Table 2. The experiment is conducted with Zhengdan 958, whose 1 000-grain weight is 327 g, as the experimental variety. The technology of one hole for two plants is adopted, and two seeds are sown in one hole. The planting density is 91 700 plants/ha when the sowing rate is 30 kg/ha.

3.2.2 Experimental design. The test date is April 20, 2015, and the test site is in the test base of Beige Village, Litianmu Hui Township, Cangxian County, Hebei Province.

Table 1 Main technical parameters of the seeder

Items	Parameters
Supporting tractors//kW	58.8 – 73.5
Suitable row spacing//cm	40/70 (wide and narrow rows)
Sowing depth//cm	2 – 5 (adjustabe)
Sowing density//plants/ha	90 000 (3 000 holes)
Maximum fertilization amount//kg/ha	300 – 1 200
Fertilization depth//cm	3 – 10 (adjustabe)
Suitable operating speed//km/h	2 – 5
Machine width//mm	2 200

The area of test site is 0.33 ha, the site is measured to be 50 m long, and 10 m stable area is kept on both sides. The working speed of tractor is 2 km/h, 3 km/h, 4 km/h, 5 km/h, 6 km/h, respectively, and 5 test areas are set up, with 3 replications. The test methods and data processing are based on the na-

tional standard *JB/T8401.1－2007 Rotary Tillage Joint Operation Machine, Rotary Tillage Fertilization Seeder*. In order to further test the operation effect, this test adds two indexes as the reference indexes to measure the operation quality: qualified rate of plastic film mulching and qualified rate of compaction degree.

Table 2 Characteristics of test materials

Items	Parameters
2BYLM-4 rotary tillage, ridging and mulching seeder	Double-plant finely seeded spoon-type seeding device, external grooved wheel-type fertilizer, 4 rows
Supporting tractors	LOVOL M1104
Corn variety	Zhengdan 958, 1 000-grain weight of 327 g
Sowing rate//kg/ha	30 (about 92 000 plants/ha)
Sowing depth//cm	3
Fertilizers	Granular slow-release compound fertilizer
Agricultural film	Polyethylene 80 cm×0.008 mm
Soil type	Loam
Terrain and slope	Basic leveling
Area of test site//ha	0.33

3.2.3 Test results. Table 3 and Fig. 3 show that with the increase of operating speed, the rate of double-plant sowing, the qualified rate of sowing depth, the qualified rate of plastic film mulching and the qualified rate of compaction degree all show a downward trend; the coefficient of variation of sowing uniformity shows a decreasing trend; the coefficient of variation of the consistency of the amount of fertilizer in different rows, the coefficient of variation of the stability of the total amount of fertilizer, and the rate of damaged seed machines, are not changed in a certain speed range, but when the speed exceeds 5 km/h, the value increases obviously.

3.2.4 Analysis of results. From the test data and analysis, we can see that: (i) Under the test conditions, the machine can achieve high speed seeding operation, the highest speed can reach 6 km/h, the quality of the operation can meet the requirements of the national standards. (ii) The rate of double-plant sowing, the coefficient of variation of sowing uniformity, the mechanical breakage rate of seed and the qualified rate of sowing depth are greatly influenced by the operating speed. The higher the speed, the worse the trend of the four indexes. When the operating speed exceeds 5 km/h, the index goes bad rapidly. (iii) The coefficient of variation of the consistency of the amount of fertilizer in different rows, and the coefficient of variation of the stability of the total amount of fertilizer, are slightly affected by the operating speed, and it can be operated at a suitable high speed when the operat-

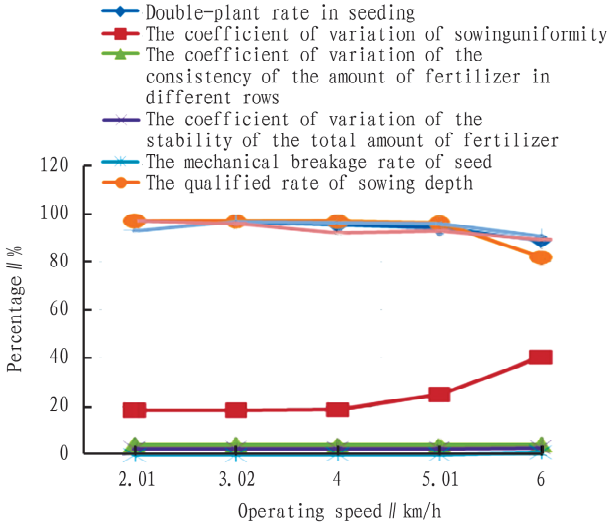


Fig. 3 Influence of the operating speed on operation quality factors

Table 3 Test results

Items	Related standards	Test data				
Operating speed//km/h	–	2.01	3.02	4.00	5.01	6.00
Row spacing//cm	–	40/70 interlacing				
Actual sowing rate//kg/ha	–	30.1				
The rate of double-plant sowing//%	–	97.12	96.80	95.52	94.35	89.27
The coefficient of variation of sowing uniformity//%	≤45	18.61	18.60	18.86	25.05	40.52
The coefficient of variation of the consistency of the amount of fertilizer in different rows//%	≤6.5	4.12	4.11	4.15	4.16	4.23
The coefficient of variation of the stability of the total amount of fertilizer//%	≤7.8	2.75	2.74	2.76	2.76	2.90
The mechanical breakage rate of seed//%	≤1.2	0.02	0.0	0.35	0.37	1.12
The qualified rate of sowing depth//%	≥75	97.18	97.05	97.02	96.51	82.20
The qualified rate of plastic film mulching//%	–	93.20	96.73	96.38	95.92	91.29
The qualified rate of compaction degree//%	–	97.20	96.01	92.28	93.36	89.75

ing conditions are allowed. (iv) Coverage rate of film mulching as a reference index makes good performance at medium speed (3 – 5 km/h), the speed too high or too low has influence on the quality of the plastic film mulching. With the increase of the speed, the qualified rate of compaction degree decreases gradually, which indicates that the qualified rate of compaction degree is high under low-speed operation.

4 Operation effect

According to the test results, the machine is optimized, the third generation improved model machine is finalized, and the performance of the machine is tested by Hebei Province Agricultural Machinery Appraisal Center. The results are shown in Table 4. Each index is superior to the national standard[6].

Table 4 Performance test results

Items // %	Related standards	Test data
The coefficient of variation of sowing uniformity	≤45	19.6
The coefficient of variation of the consistency of the amount of fertilizer in different rows	≤6.5	4.74
The coefficient of variation of the stability of the total amount of fertilizer	≤7.8	2.85
The mechanical breakage rate of seed	≤1.2	0
The qualified rate of sowing depth	≥75	95

In 2016, the small batch production of the machine was completed, the large area sowing experiment was carried out, and the yield was measured in the demonstration base of Hebei Academy of Agricultural Sciences (Fig. 4). The average yield reached 8 523 kg/ha, 20.6% higher than that of the control.

Note: a. Sowing operation; b. Operation effect; c. Seedling emergence; d. Plant growth; e. Spike growth

Fig. 4 Operation effect of the seeder

5 Conclusions

(i) In this study, the influence of seeder operating speed on operating quality parameters is tested at 2 – 6 km/h. The rate of double-plant sowing, the coefficient of variation of sowing uniformity, the mechanical breakage rate of seed, and the qualified rate of sowing depth, show a decreasing trend with the increasing working speed, and the index obviously goes bad when working speed exceeds 5 km/h. The coefficient of variation of the stability of the amount of fertilizer is slightly affected by the operating speed. The qualified rate of plastic film mulching is the best at medium speed (3 – 5 km/h). The qualified rate of compaction degree decreases gradually with the increase of speed, and the qualified rate of compaction degree is high in low-speed operation.

(ii) 2BYLM-4 rotary tillage mulching seeder for spring corn is a new type of combined working machine produced, researched and developed for spring corn production in dryland. It fully meets the agronomic requirements and realizes the integration of farming machine and agronomy.

(iii) According to the technical requirements of ridge-mulching and side-sowing of spring corn, this machine applies the technology of one hole for two plants to rainfed farming in dry zone, achieving a new breakthrough.

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