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Research Article

Design and Experimental Study of Spoon-Clamping Type Garlic Precision Seeding Device

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In order to realize the mechanized sowing operation of garlic and ensure that the position of garlic scales is planted upright-position, a spoon-clamping type garlic precision seeding device is designed. The device is composed of seed box, seeder, righting fittings, and so on. This paper adopts the method of theoretical analysis; combined with the characteristics of garlic, the key components of the sowing device have been optimized and designed; and the final form of the device is determined. The one-factor experiment and multifactor experimental studies were carried out, and the optimal working parameter combination of the device was obtained by using the response surface methodology and mathematical modeling method, and finally, the optimized working parameter combination was verified. The results showed that the spoon-clamping type garlic sowing device could meet the operational requirements of garlic mechanized sowing. This study has certain theoretical and practical significance for the mechanization development of garlic.

1. Introduction

Garlic is a famous food and medicine plant, together with ginseng and ginkgo biloba, called the three major functional foods of the 21st century. In recent years, garlic functional ingredients have become a hot topic in the research of medical research institutions in many countries [1–3]. In developed countries such as the United States, garlic pharmaceutical products tend to replace antibiotic products [4–6]. China is the world's largest garlic grower, accounting for more than 60% of the world's sown area and about 70% of the world's output. Chinese garlic sowing requires "one grain for one hole, upright-position sowing" which is a higher yield model, but the existing machinery only has the ability to sow garlic but lacks the ability to right the garlic seeds. Therefore, the garlic metering device not only needs to meet the precision sowing but also needs a certain structural device to achieve the operation requirements of garlic scales facing upright-position. At present, there are three main problems that need to be solved urgently in the vertical sowing technology of garlic concentrate. One is how to improve the effect of single-grain seeding and how to achieve the operational requirements of precision sowing. The other is how to achieve garlic seed orientation and improve the pass rate of orientation. The third is how to do a good job of orientation of garlic seeds to sow upright-position into the soil.

In the 1940s, European and American countries began to carry out research on precision metering device, and some products of the Brazilian company Baldan were equipped with horizontal disc types of metering device by replacing different types of hole row for metering plate to apply to the sowing of different crops, with good versatility [7]. The German Schmotzer UD2000 seeder is equipped with a tilt disc seeder, which works well at low speeds. Spoon wheel type metering device has gradually faded out in European and American countries. Relatively speaking, the clip finger type of metering device has higher operation accuracy, relatively fast operation speed, and higher acceptance. Kinze and Precision Planting Company's clip finger type of metering device in the United States is widely used in metering device and is continuously optimized through technical improvements. Kinze Company is reducing the replay rate. Extensive optimizations have been made to reduce seed breakage and bounce underrunning caused by collisions [8]. Precision planting has made extensive optimizations in improving the adaptability of clip finger type of metering device sets to seeds of different shapes and reducing seed breakage and bounce leakage caused by collisions at finger clip discharge ports [9]. Wang et al. compared the coefficient of variation of different metering device by the angle of inclination of the surface and found that the operation effect of the clip finger type of metering device was least affected by the angle of inclination of the surface, but it was greatly affected by the size of the seeds, and the large seeds were not easy to be clamped, which was easy to cause leakage, and the small seeds were easy to cause replay. At the same time, due to the limitations of mechanical structure, the maximum working speed of the clip-on type seeder is 7-9 km/h [10].

In the 1960s, foreign countries applied garlic sowing machinery on a large scale and conducted many studies on garlic sowing machinery and key technologies [11–18]. There are two main types of foreign garlic sowing machinery: mechanical type and pneumatic type, of which mechanical type is divided into artificial semiautomatic type, rotary spoon type, pressure hole type, plug-in type, and pneumatic type mainly air suction type. Japan Yanmar launched a PH4-R type garlic seeder and manually planted in the rubber seed hole, and then, the seed hole plate is flattened downwards. When it is close to the ground, the row clock pusher inserts the garlic seed into the soil. The test shows that the machine has problems such as wounded garlic, low erectness, sowing too deeply, and forming a long spacing after sowing, which is not in line with China's sowing habits [19]. Handheld garlic seeder is developed by Tarun et al. and Nare et al. of Punjab University in India [20–21], the operating speed is 1.8 km/h, and single-grain sowing is achieved by vibration, but upright-position sowing cannot be carried out, this type of machine has a simple structure, and the price is cheap, but the degree of automation is low. In addition, Devesh et al. and Jiraporn et al. [22, 23] studied the speed of such garlic planters. The garlic seeder produced by Spanish Baoqi J.J. Borch Company evenly distributes the seeding spoon controlled by the twist spring on the edge of the metering plate, and the rounded arc garlic spoon is distributed on the side of the turntable, and the control of the twist spring is realized through the limit block, to realize the seed collection and seeding operation. Excess seeds are brushed off by the seed brush and dropped back into the seed box. It is efficient and simple to operate but has no requirements for upright-position and is expensive. Mainly represented by Japan and Korea, the hemispherical surface-shaped holes are first pressed out mechanically, and then, the garlic cloves are sown into the pressed garlic holes, and the direction of garlic scales is controlled through the sphere in the garlic caves. The PLMS3 and PLP3 garlic metering devices produced by emma ERME in France and the Czech Sloh are now also commonly used in the press-hole synchronous garlic metering device. The YD1500 garlic grower produced in South Korea ensures the automatic feeding of garlic head and the upright-position entry of scale buds into the soil through seed extraction mechanism, seeding mechanism, direction control mechanism, and antisqueeze mechanism, which effectively solves the common problems such as blockage and damage to garlic head during sowing. However, due to the uneven budding, it has not been promoted. Garlic metering device produced in France and Czechoslovakia uses specific mechanisms to straighten the garlic head and vibrate jitter tank directionalizers to solve the orientation problem of garlic seeds in the conveying process. This technique basically solves the problem of scaly orientation, but the scaly erection requirements are not guaranteed, and the mechanism is complex and large [24].

In summary, most of the research is mainly the design of the garlic seeding machine seeding structure, the garlic seeder in Western countries cannot achieve garlic upright-position sowing, and some studies in Asian countries have considered the performance of the garlic seeder single-grain seeding and paid attention to the problem of sowing upright-position, but the actual effect is not ideal. Therefore, this paper designs a garlic sowing device suitable for the requirements of Asian garlic sowing, which has certain value and significance for the research related to garlic upright-position sowing.

2. Device

2.1. Overall Structure and Working Principle. The spoon-clamping type garlic precision seeding device is mainly composed of a seed box, a spoon-clamping type seeder, and a righting fittings, and the overall structure is shown in Figure 1.

The metering plate is mounted on the support by the spindle, which can be rotated around the spindle, and each seeding spoon is installed on the metering plate holder by means of a twisting spring, and the twisting spring and the seeding spoon are distributed on both sides of the metering plate. During the work, the seeding disc drives the clamping shaft, the clamping torsion spring, and the clamping rotary spoon to carry out a circular movement. The seeding spoon can provide the seeds with axial pressure along the metering plate and the power along the direction of the metering plate to achieve seed carrying under the action of the twisting spring, and the vertical plate surface2 is provided on the metering plate one limit lever, 1 for toggling the torsion spring spindle to control the opening and closing of the seeding spoon to achieve seeding and the other one to control the opening and closing of the seeding spoon by toggling the torsion spring core shaft to achieve seeding. When the clamping rotor spoon rotates to the position of the clamping limit block below the seed box, the clamping rotor spoon is controlled by the clamping shaft, so that it is in an open state, and the seeding is taken by the clamping rotor when the clamping shaft passes through the clamping limit block through the elasticity of the clamping spring. When the seed transfer spoon movement to the top of the metering plate through the seed cleaning brush, the seed cleaning brush sweeps away the excess carrying and clamping unstable seeds, so as to achieve the seed removal process, when the seed transfer spoon is clamped. When the garlic seed is rotated to the position of the seeding limit block, the clamping spindle opens the clamping spoon to make the garlic seed fall freely and enter the directional righting fittings.

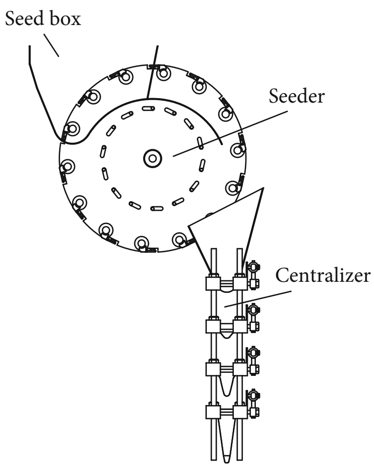


Figure 1: Spoon-clamping type garlic sowing device.

2.2. Key Component Design

2.2.1. Row of Metering Plate Design

(1) The Number of Seeding Spoon. Garlic seeder in the operation process mainly relies on the ground wheel transmission and sowing process: garlic seeds on the one hand with the row of metering plate to do a fixed axis rotation, the randomizer forward process to do linear movement on the other hand, according to the function of "coordination, synchronization, and consistency" principle, and then the row of seeds on the metering plate. The arc of garlic seed rotation should be equal to the time of one hole distance between the seeder and the planter.

$$\begin{cases} S_p = r\theta = \dfrac{n_p d_p \pi t}{60}, \\ S_c = (1+\delta) v_c t, \end{cases} \tag{1}$$

where S_p is the arc length between metering plate and spoons, m; v_c is the seeder forward speed, m/s; S_c is the garlic plant spacing, m; δ is the ground wheel slip rate; and t is the forward time, s.

Union obtains

$$S_p = \frac{S_c n_p d_p \pi}{(1+\delta) 60 v_c}. \tag{2}$$

For the garlic planting agronomic requirements, plant spacing$S_c$is 80-120 mm, seeder forward speed$v_c$is 1-2 km/h, and the slip coefficient of the ground wheel is ranged 0.05~0.12; take the δ =0.08. Then, the long distance between the S_p row of seeds between the pans and spoons is 116-58 mm.

$$\mathrm{n}_s = \frac{\pi d_p}{S_p}, \tag{3}$$

where n_s takes the number of seeding spoon, Ge.

Then, the arc length between the spoons on the metering plate was determined to be 116 mm, and the number of seeding spoons was 14.

(2) The Diameter of the Row Metering Plate. The diameter of the metering plate is larger, and the seeding spoon is more, which can reduce the angular velocity of the metering plate. It is conducive to the performance of the seed; on the other hand, the seed carrying process of the seeding spoon mainly relies on the spring stretching effect, and the growth in the diameter of the metering plate can increase the amount of spring deformation and improve the process extrusion force of the seeding spoon, but also it will make the seeding mechanism increase accordingly, and the self-weight increases. While the power consumption increases, the diameter d_p of the metering plate takes 520 mm.

(3) The Seeding Spoon Maximum Line Speed to Determine. The line speed of the metering plate refers to the line speed at the seeding spoon of the metering plate. The speed of the metering plate is higher, the linear velocity is greater at the seeding spoon, the time for the seeding spoon to pass through the seed area is short, the time to take the seeding spoon is too late to take the seed, the speed is large and the impact of other seeds is large, and there are seeds that have been taken. After being affected by the large impact of other seeds, it is easy to fall and cause holes. Therefore, the linear speed of the metering plate to take the seeding spoon should generally not be greater than 0.35 m/s. In order to improve efficiency, the maximum line take-off speed is 0.35 m/s.

$$\frac{d_p n_p \pi}{60} = 0.35\ \mathrm{m/s}, \tag{4}$$

where d_p is the row of seed disc diameter, m, and n_p is the row disc speed, r/min.

Therefore, the maximum value of n_p is 13 r/min.

(4) The Position of the Seeding Port of the Seeder. The placement port position is determined by analyzing the movement of the seeding process, as shown in Figure 2. Set the horizontal displacement of the seeder seeding process to x and the vertical displacement to y.

$$\begin{cases} x = r_p \omega_p \cos\theta, \\ y = r_p \omega_p \sin\theta + \dfrac{g t^2}{2}, \end{cases} \tag{5}$$

where r_p is the row of metering plate radius, mm; ω_p is the row disc angular velocity, rad/s; x is the horizontal displacement of garlic seeding, mm; y is the vertical displacement of garlic seeding, mm; and θ is the garlic seeding angle, rad.

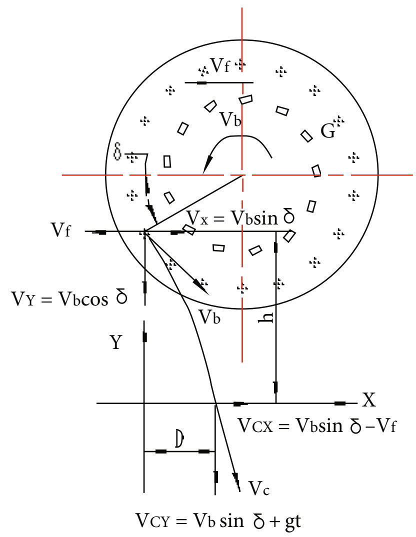


Figure 2: Motion analysis of the seeding process.

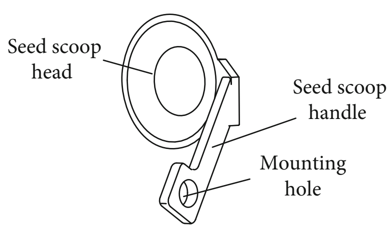


Figure 3: The structure diagram of the seeding spoon.

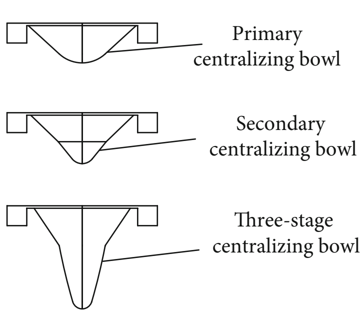


Figure 4: Righting fitting structure.

In order to reduce the horizontal speed of the seeding process, the horizontal displacement is zero, so the seeding port is set at A, the rightmost level of the metering plate, and θ is 90°. The expression of displacement and end velocity of garlic seed seeding process is as follows.

$$\begin{cases} x = 0, \\ y = \omega_p r_p t + \dfrac{gt^2}{2}, \\ v_t = \sqrt{\omega_p^2 r_p^2 + 2gy}. \end{cases} \quad (6)$$

It can be seen from the formula that the garlic seed casting process is vertical linear motion, the displacement changes with time in a quadratic curve, and the final velocity and conical increase with the growth of displacement.

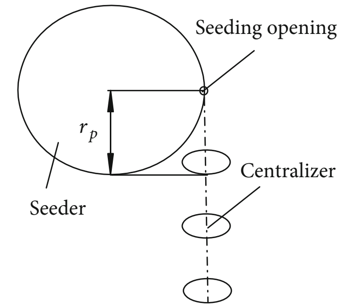


Figure 5: Position diagram of the righting fittings.

2.2.2. Take the Seeding Spoon Design. The seeding spoon consists of the seeding spoon head, the seeding spoon handle, and the mounting hole, as shown in Figure 3. The seeding spoon head is a bowl-shaped structure, and its diameter is based on the design of the three sizes of garlic seeds, and it is finally determined that the diameter of the seeding spoon should be between 20 mm and 40 mm.

2.2.3. Design of the Righting Fittings

(1) Righting Fitting Structure. The righting fittings is divided into three stages, which are composed of different forms of righting bowls, as shown in Figure 4.

(2) The Horizontal Position of the Righting Fittings. In order to reduce the horizontal speed of the seeding process, the righting fittings is set directly below the seeding port so that the centerline of the seeding port and the centerline of the righting fittings are in a vertical line, as shown in Figure 5.

(3) The Vertical Height of the Righting Fittings. According to the determination of the position of the planting water level, the speed at which the garlic seeds can be put into the first stage of the correction device is as follows.

$$v_1 = \omega_p r_p + gt = \omega_p r_p + \sqrt{2gy}. \quad (7)$$

It can be seen from the above formula that when the garlic seeds are put into the first stage of the righting fittings, the speed v_1 is related to the angular velocity of the metering plate, the radius of the metering plate, and the vertical height. When the radius is fixed, the smaller the vertical height, the speed is smaller when the first level of righting fittings is put into place, so the smaller the vertical height, the better; the secondary collision and rebound can be avoided, and finally, the vertical height size y is determined as the radius of the metering plate r_p.

3. Experimental Study on Sowing Performance of Garlic

3.1. Test Materials and Equipment. The test materials selected "A-cheng purple garlic" widely planted in Heilongjiang region

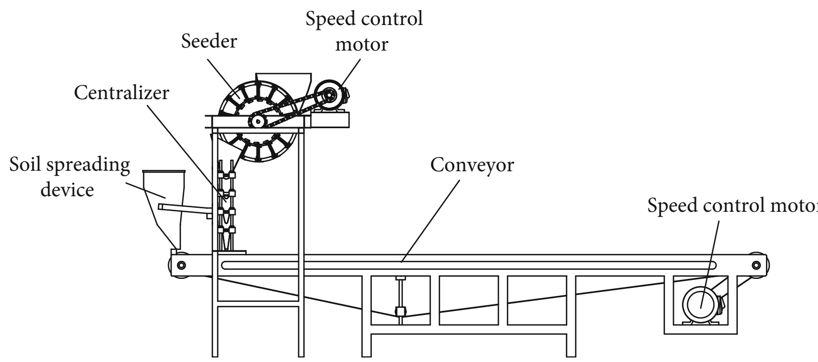


Figure 6: Spoon-clamping type garlic precision seeding test bench.

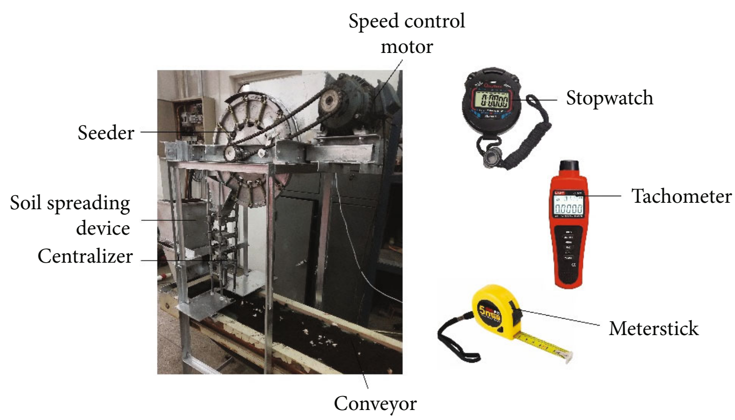


Figure 7: Spoon-clamping type garlic precision seeding device test bench physical diagram and measurement equipment.

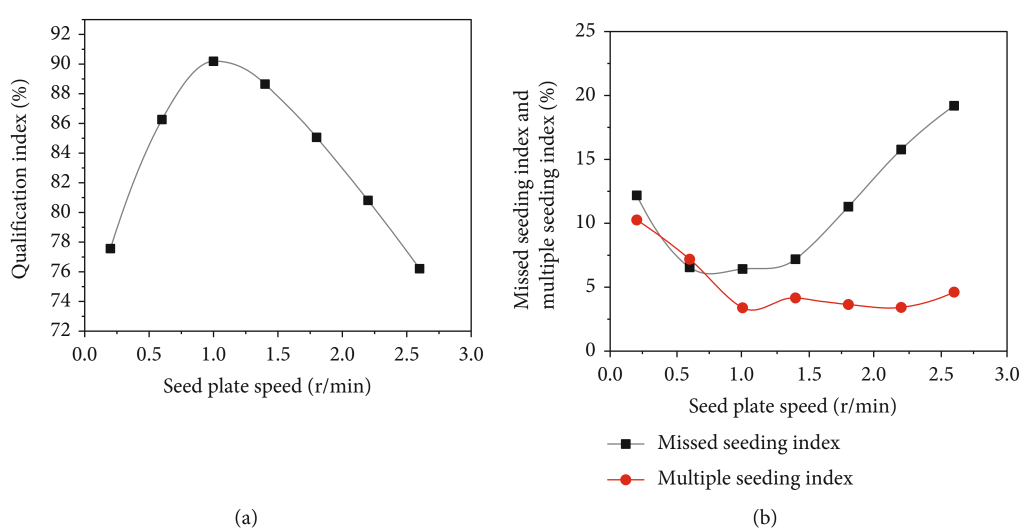
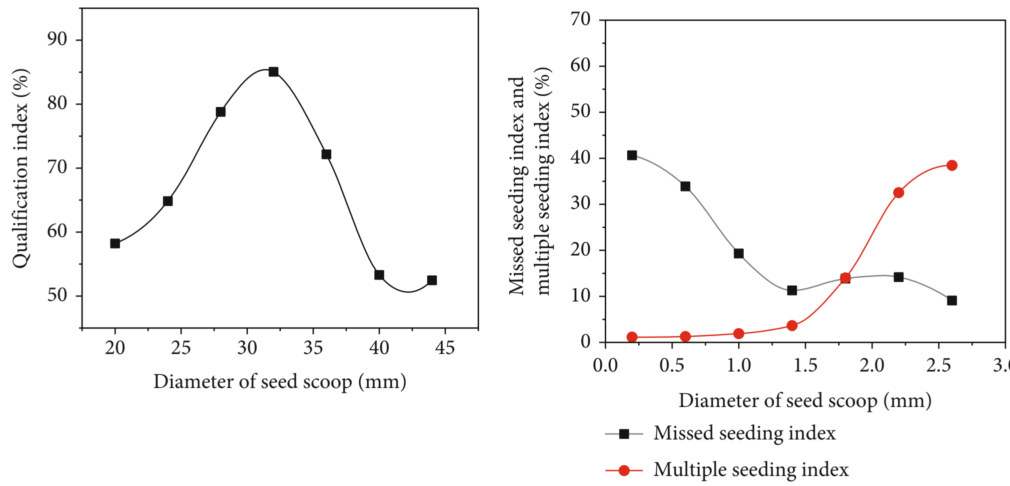


Figure 8: One-factor test result curve of row seed disc speed. (a) The impact of the speed of the metering plate on the pass index of seed extraction. (b) The impact of the speed of the seed disc on the missing and replay index.

as the test variety, and the moisture content of the garlic species for testing was controlled at 10%-20% through artificial grading screening. And the appearance is full and symmetrical, without scars, decay, and insect infestations. According to the above selection principles, garlic seeds with similar specifications were selected for one-factor test, multifactor test, and verification test of seeding device performance.

The test device adopts the self-made spoon-clamping type garlic precision seeding test bench, and its overall structure is shown in Figure 6, which mainly includes the spoon



(a) (b)

FIGURE 9: One-factor test result curve for spoon diameter. (a) The impact of the diameter of the seeding spoon on the pass index of the seed extraction. (b) The impact of the diameter of the seeding spoon on the leakage and replay index.

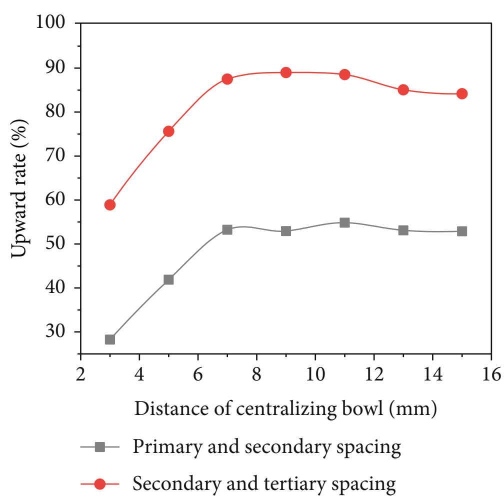


FIGURE 10: One-factor test result curve of the bowl spacing.

clip type garlic concentrate seeder, the three-stage righting fittings, the soil laying device, the conveyor belt, and the speed regulation motor. The garlic seeder and the righting fittings complete the extraction and righting fittings of the garlic seed. The soil laying device evenly lays the soil on the conveyor belt, so that the garlic seed falls into the soil of the conveyor belt after being straightened by the righting fittings, and the spatial morphological characteristics of the garlic seed are maintained to simulate the actual field operation state of the garlic seeder.

In addition to the self-made spoon-clip garlic precision seeding test bench during the test process, it also involves test equipment for measuring and adjusting the working parameters of the test bench, including stopwatches, tape measures, and UT372 speed meter (measuring range 0 ~ 999 r/min). The physical diagram and measuring equipment of the spoon-clamping type garlic precision seeding device test bench are shown in Figure 7.

3.2. Test Factors and Evaluation Indicators. The main factors affecting the operation quality and suitable sowing range of the spoon-clamping type garlic precision seeding device are the working speed of the metering plate, the diameter of the seeding spoon, the spacing of the first and second level correction devices, and the spacing of the two or three levels of correction. Therefore, this study will carry out experimental research on the optimization of seed scheduling performance with the above four factors, namely, one-factor experiment test and multifactor test, in order to further explore the pair of structural parameters and working parameters of the seeder. The performance of the seeding is affected, and the optimal combination of operating parameters of the seeder is obtained. The evaluation index selected the pass index, the missed sowing index, the repeat sowing index, and the garlic scale bud facing upward index. The calculation formula of each performance index is as follows:

$$\begin{cases} \text{Pass index}: S = \dfrac{n_1}{N'} \times 100\%, \\ \text{Repeat sowing index}: D = \dfrac{n_2}{N'} \times 100\%, \\ \text{Missed sowing index}: M = \dfrac{n_0}{N'} \times 100\%, \\ \text{Garlic scale bud facing upward index}: U = \dfrac{n_u}{N'} \times 100\%, \end{cases} \tag{8}$$

where S is the pass index, D is the repeat sowing index, M is the missed sowing index, U is the garlic scale bud facing upward index, n_1 is the qualified quantity of single seed seeding, n_2 is the quantity of two or more seeds, n_0 is the number of missed seeding, and n_u is the number of garlic seeds with scale buds upward.

3.3. Univariate Experimental Studies

Table 1: Horizontally coded table of multivariate experimental factors.

Level encode	Experimental factors			
	Working speed x_1 (r/min)	Take the diameter of the seeding spoon x_2 (mm)	The spacing between the first and second level of the correct bowl x_3 (mm)	Two or three levels of correct bowl spacing x_4 (mm)
+2	1.8	40	110	110
+1	1.4	36	90	90
0	1	32	70	70
-1	0.6	28	50	50
-2	0.2	24	30	30

Table 2: Multivariate test protocols and results.

Serial number	Experimental factors				Test indicators			
	x_1	x_2	x_3	x_4	and1	and2	and3	and4
1	-1	-1	-1	-1	78.5	18.42	3.08	85.41
2	1	-1	-1	-1	80.87	17.99	1.14	79.23
3	-1	1	-1	-1	78.34	8.95	12.71	86.11
4	1	1	-1	-1	84.53	8.31	7.16	80.29
5	-1	-1	1	-1	79.34	19.14	1.52	87.5
6	1	-1	1	-1	79.11	19.56	1.33	81.07
7	-1	1	1	-1	69.42	8.98	21.6	88.11
8	1	1	1	-1	76.1	9.16	14.74	89.62
9	-1	-1	-1	1	76.49	19.34	4.17	89.12
10	1	-1	-1	1	77.4	18.74	3.86	83.5
11	-1	1	-1	1	71.24	10.05	18.71	89.02
12	1	1	-1	1	74.8	9.10	16.1	84.01
13	-1	-1	1	1	71.49	21.49	7.02	90.5
14	1	-1	1	1	74.37	21.02	4.61	84.08
15	-1	1	1	1	58.78	12.21	29.01	92.1
16	1	1	1	1	62.6	10.87	26.53	91.5
17	-2	0	0	0	77.56	12.18	10.26	94.11
18	2	0	0	0	85.06	11.30	3.64	78.74
19	0	-2	0	0	64.84	33.89	1.27	95.48
20	0	2	0	0	53.29	14.19	32.52	95.39
21	0	0	-2	0	82.24	11.36	6.4	91.5
22	0	0	2	0	77.47	14.16	8.37	95.38
23	0	0	0	-2	91.35	7.54	1.11	84.5
24	0	0	0	2	78.92	10.47	10.61	92.71
25	0	0	0	0	89.57	3.46	6.97	96.45
26	0	0	0	0	86.46	3.72	9.82	95.06
27	0	0	0	0	89.92	3.26	6.82	96.16
28	0	0	0	0	88.81	3.5	7.69	96.51
29	0	0	0	0	89.97	3.36	6.67	95.5
30	0	0	0	0	89.26	3.71	7.03	96.62

3.3.1. The Working Speed of the Row Metering Plate Affected the Performance. The control variable method is used to explore the influence of the working speed of the metering plate on the performance of the seeding, and the working speed of the metering plate is set to be kept under the conditions of 32 mm diameter of the seeding spoon and other working conditions 0.2 r/min, 0.6 r/min, 1 r/min, 1.4 r/min, 1.8 r/min, 2.2 r/min, and 2.6 r/min seven levels; each level of the test was repeated 3 times, the seed pass index, missed sowing index, and replay index for statistical analysis; the test results take the average. The results of the one-factor test of the working speed of the seeding disc are shown in Figure 8.

3.3.2. The Diameter of the Seeding Spoon Affected on the Performance. The control variable method is used to explore the influence of the diameter of the seeding spoon on the performance of the seeding, and the diameter of the seeding spoon is set at seven levels of 20 mm, 24 mm, 28 mm, 32 mm, 36 mm, 40 mm, and 44 mm. Each level of the test was repeated 3 times, the seeding pass index, missed index, and replay index for statistical analysis; the test results take the average. The results of the one-factor test on the diameter of the seeding spoon are shown in Figure 9.

3.3.3. The Spacing of the Righting Fittings Affected the Performance. The one-factor experimental study was carried out with the spacing of the righting fittings as the test factor. The spacing between the first and second level positive bowls and the second and third level positive bowls is set at seven levels of 30 mm, 50 mm, 70 mm, 90 mm, 110 mm, 130 mm, and 150 mm, respectively. Keeping other working conditions the same, each level of the test was repeated 3 times, garlic scaly buds facing up rate of evaluation indicators for statistical analysis; the test results take the average. The results of the one-factor test on the spacing of the righting fittings are shown in Figure 10.

According to the influence of various factors on the sowing performance of garlic in the univariate test, the zero-level value of each test factor was determined. Therefore, the follow-up multifactor test was based on the working speed of the metering plate 1 r/min, the diameter of the seeding spoon was 32 mm, the first and second stage correction device was 70 mm, and the second and third stage correction device was 70 mm which is a zero-horizontal value.

3.4. Multivariate Experimental Studies

3.4.1. Test Protocol and Results. In this study, a four-factor five-level quadrature rotational combination test protocol by the Design-Expert 6.8.10 was used. The statistical analysis of the test scheme design and test results was carried out; this paper establishes a mathematical model between the sowing performance indicators and the test operation parameters and finally solves the spoon-clamping type garlic sowing device optimal combination of job parameters.

The horizontal coding of the multivariate test factors is shown in Table 1, and each group of trials was conducted

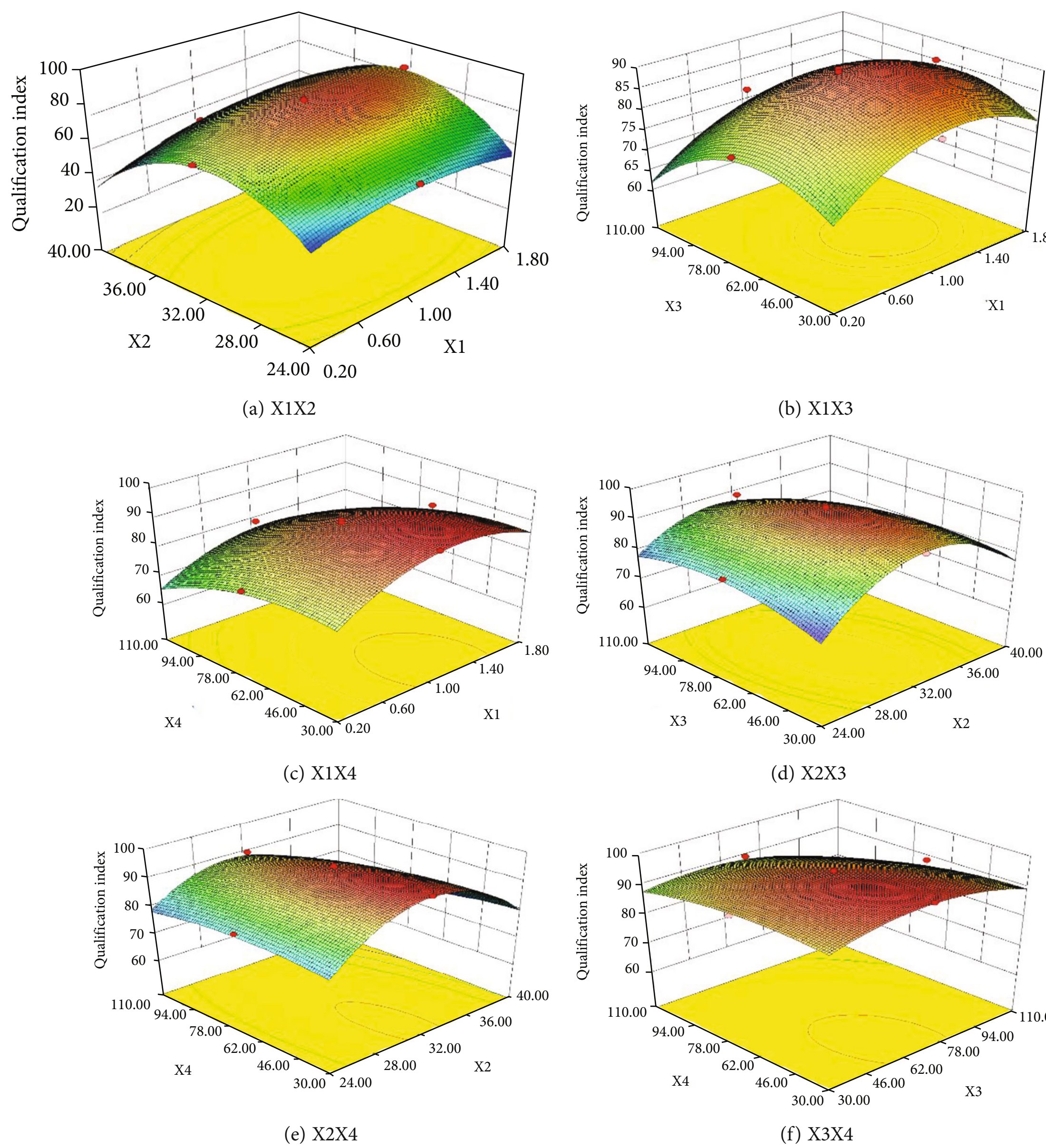


Figure 11: Pass index response surface plot.

three repeated trials, and the data were averaged as the test results. Among the test factors, x_1 is the working speed, x_2 is the diameter of the seeding spoon, x_3 is the spacing of the first and second stage righting fittings, x_4 is the spacing of the two- and three-level righting fittings, y_1 is the plant distance qualification index, y_2 is the missing index, y_3 is the replay index, y_4 is the garlic scale bud facing up rate, and the multifactor experiment is the specific test scheme. And the results are shown in Table 2.

3.4.2. Surface Analysis of the Conformity Index Response. When analyzing the influence of any two factors on the experimental indicators, the other factors are set to zero horizontal values, and the influence of the interaction of the two factors on the experimental indicators can be explored. Therefore, to explore the influence of various factors on the conformity index of plant spacing, the response surface plot is drawn by using the Design-Expert 8.0.6, as shown in Figure 11.

3.4.3. Optimization of Job Parameters. The Design-Expert 8.0.6 software is used to optimize the plant distance pass index, replay index, missed sowing index, and garlic scaly bud up rate and set the optimization conditions for the plant distance pass index, and garlic scaly bud facing up rate is the largest, replay index and missing index are the smallest, and the nonlinear mathematical model constraints are established as shown in Equation (8); plant distance pass index, missing index, replay index, and garlic scale bud facing up the rate important index are solved at 4 : 5 : 2 : 4.

$$\begin{cases} s.t. \begin{bmatrix} 0.2\text{r/min} \leq x_1 \leq 1.8\text{r/min} \\ 24\text{mm} \leq x_2 \leq 40\text{mm} \\ 3\text{mm} \leq x_3 \leq 11\text{mm} \\ 3\text{mm} \leq x_4 \leq 11\text{mm} \end{bmatrix} \\ \text{MAX} \qquad\qquad Y1, Y4 \\ \text{MIN} \qquad\qquad Y2, Y3 \end{cases} \quad (9)$$

According to the model, the optimal working parameter combination is as follows: the speed of the seeding disc is 1.02 r/min, and the diameter of the seeding spoon is 32.22 mm. The spacing between the first and second level correction devices is 62.11 mm, and the spacing between the second and third level correction devices is 59.56 mm. Moreover, in theory, the best sowing performance was 91.06% of plant spacing pass index, 3.38% of missing sowing index, 5.81% of replanting index, and 94.14% of garlic scaly bud facing.

3.5. Verification Test. In order to verify the sowing performance of the optimal parameter combination and verify the accuracy of the optimization model, a verification experiment is carried out. The working speed of the seeder is set to 1.02 r/min, the diameter of the seeding spoon is 32 mm, the spacing of the first and second level correction devices is 62 mm, and the spacing of the second and third level positive devices is 60 mm. Each set of experiments was repeated for 5 times, and the final yield was 90.75% of plant spacing pass index, 3.96% of missing sowing index, 5.29% of replanting index, and 94.88% of garlic scales facing up. It can be seen that the verification test results are basically consistent with the optimization results, which proves the feasibility of the model, and the spoon-and-clip garlic precision seeding device can meet the agronomic requirements of garlic sowing.

4. Conclusions

In this paper, a mechanized seeding device of garlic with the function of righting fittings is optimized to realize the mechanized planting of garlic and ensure that the scales of the planted garlic are oriented upright-position. The process uses the spoon-clamping type garlic seeding device to realize the automatic extraction of garlic seeds, and the removed garlic seeds enter the three-level correction device, and under the adjustment effect of the three-stage positive device, the scale buds are planted upright-position.

Using theoretical analysis, this paper completes the design and optimization of the device combined with the characteristics of garlic, which carries out univariate and multifactor experimental studies and verifies the sowing performance of the device. The results show that with the use of the device for garlic sowing operations, the indicators can reach 90.75% of the qualification index, the omission index is 3.96%, and the replay index is 5.29%. The upward rate of garlic scale buds is 94.88%, indicating that the spoon-clamping type garlic precision seeding device can meet the agronomic requirements of garlic sowing.

5. Discussion

There is still room for further optimization of the centralizer. The righting device mentioned in this study mainly utilizes the volume, shape, and inertia of garlic seeds and is realized through the natural overturning of the falling distance process and the receiving form of the righting bowl. If the garlic seeds are uniform in form, the passing rate of this solution can meet the production demand, while for some forms of garlic seeds, the natural turning cannot be relied on to achieve the righting. So in the following research, tools such as image recognition and neural networks can be applied to upgrade and optimize the process.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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