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# Research status and development trend of seed-metering device in China

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### ABSTRACT

As the main tool of soybean mechanization production, the performance of soybean seeder is directly related to the sowing quality and yield of soybean. As the core component of the seeder, the soybean seed-metering device directly affects the seeding accuracy, uniformity, seed emergence rate, etc. This article introduces the research status and future development trend of soybean seed-metering devices in China in recent years, analyzes the characteristics of soybean seed-metering devices in China, and provides a basis for the further development of seed metering devices in China.

**Keywords:** soybean seed-metering device; research status; development trend

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## Introduction

Soybean mechanical seeding is an important link in the mechanized production of soybeans. According to the agronomic requirements of soybean seeding, the soybean seeder must plant the soybeans in the shortest time according to the precise number of holes, the spacing and the depth of sowing. In the holes, the seeds sown in the holes are required to meet the requirements of the number of holes, so that the growth of soybeans has good conditions. The use of mechanical seeding can ensure that the seeds are distributed reasonably in the field, the plant spacing is uniform, the amount of sowing is accurate, and the depth of sowing is consistent, thereby creating a good environment for the growth and development of seeds<sup>1</sup>.

## Type and working principle of seed-metering device

### device

At present, the commonly used soybean seed-metering devices in China are mainly eye-wheel type, belt-hole type, spoon type, air suction type, air blowing type, air pressure type, etc. According to their working principle, they can be divided into mechanical type and pneumatic type. Among them, the mechanical seed-metering device mainly includes an eye wheel type, a hole type, a spoon type and the like. When the socket-type seed-metering device (as shown in Figure 1) works, the seeds in the seed cylinder fall into the socket of the socket-eye wheel by their own gravity, and the excess seeds are scraped off by the seed scraper for cleaning, relying on gravity either push the seeder into the seed pipe, or directly fall into the seed ditch for seeding.



**Figure 1 Socket-eye seed metering device**

The shape of the hole is mainly cylindrical, conical and circular. In order to facilitate seed filling and reduce seed damage during scraping, the bore with a front groove, tail groove or chamfer. The larger the filling angle, the longer the filling distance, the more chance the seeds enter the nest eye, the better the filling effect. Generally less than or equal to 0.2 m/s. The hole of the belt-type seed metering device is located on the seeding tape. When the seed moves with the hole to the bottom of the seed cleaning wheel, the seed wheel is cleaned by the seed wheel

rotating in the opposite direction of the movement of the seed tape, and then the seed enters the hole. The seeding area falls into the seed ditch by its own gravity. The seeding device has a low sowing injury rate and good uniformity of grain distance. Its disadvantage is that it has strict requirements on seeds and is not suitable for high-speed operations. The spoon type seed-metering device (shown in Figure 2) relies on the scoop-type structure on the seeding tray to take out the seeds from the seed chamber, and the extra seeds will fall by gravity to

complete the seed chamber. The seeds are discharged from the seed metering device under the action of gravity and centrifugal force and fall into the seed ditch to complete the whole

seeding process. The advantage of the spoon type seed-metering device is that it can adapt to high-speed operation.



**Figure 2 Spoon type seed-metering device**

The structure of the pneumatic seed-metering device is relatively complicated, but it overcomes the shortcomings of the mechanical seed-metering device mentioned above. It has low requirements on the size of the seeds, does not require strict grading treatment of the seeds, is easy to realize single seeding, and can adapt to high-speed seeding requirement, not easy to damage the seeds, is a more advanced sowing technology. Pneumatic seed metering device mainly includes air suction type, air blowing type and air pressure type.

The air-suction seed-metering device (shown in Figure 3) uses the principle of vacuum suction. When the seeding disc rotates, the negative pressure generated by the vacuum chamber attracts the seeds to the seeding disc and rotates with the seeding disc. When the seed is transferred to the seeding area below the seeding device, this area is outside the vacuum chamber and there is no longer any adsorption force. The seed falls into the seeding groove due to its own gravity. The air-suction seed-metering device has high requirements on the airtightness of the vacuum chamber, and it is easy to wear.



**Figure 3 Suction seed-metering device**

The air-blowing seed-metering device utilizes the effect of positive pressure. When the seeds in the seed box enter the mold hole of the seed plate, the seeds are closely attached to the mold hole under the action of the pressure difference, and when they reach the seeding area, the seeds are not subject to the pressure of the air current and fall to the seed ditch by their own gravity. This type of seeding device can sow seeds that are not selected and graded, and has lower requirements for air tightness compared to air suction.

The principle of the air-type seeder is similar to the air-blowing type. The positive pressure provided by the airflow is used to form a pressure difference to make the seeds adhere to the seeding plate. When the seeds enter the seeding area, the seeds are no longer subject to the pressure of the airflow. Dead weight falls into the seed ditch. Pneumatic seed-metering device works reliably and has good uniformity.

### **Research status of Chinese soybean seed-metering device**

At present, there are a variety of techniques for soybean planting operations in China. The three cultivation techniques of "ridge three", "dark ridge density", and "large ridge density" are commonly used in the northeast region<sup>2</sup>, and no-tillage in autumn is mainly used in Huanghuaihai area. In the sowing mode, as long as the early crops of soybeans are early-maturing crops such as corn and wheat, the land area in the south is relatively small, and the hilly areas are not convenient for large-scale machinery. Moreover, the planting mode is mostly intercropping and interplanting, and only small machinery can be used. According to different operation development models, China's soybean seed-metering equipment has been researched and developed accordingly.

Since the 1970s, China began to study soybean seed meters. Through the introduction and self-development of a variety of seed meters with different structures and working principles, they are generally divided into two

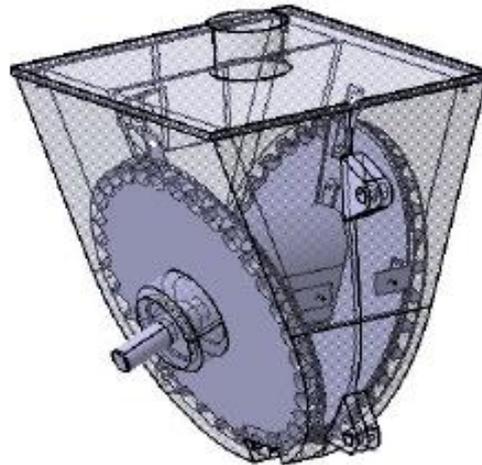
types: mechanical and pneumatic. Affected by China's planting model and production requirements, mechanical seed meters are widely used in China and are developing rapidly<sup>3-6</sup>. In the past ten years, the mechanical seed-metering device has developed rapidly. Chen Yulong<sup>7</sup> and others designed a convex spoon seed-metering device. On the basis of the traditional disc seed-metering device, the structure of the seed sampling part was improved. As the seeding structure, it protrudes outside of the seeding plate. During the seeding process, the seeds enter the convex spoon along the tangential direction of the seeding plate. The excess seeds in the spoon fall back to the seed chamber by their own weight. Because the opening direction of the convex spoon is along the tangential direction of the seeding disc, which is consistent with the direction of the seed filling movement, the seeding time is inversely proportional to the speed of the seeding disc. When the speed of the seeding disc increases, the seeding time decreases, so this seed-metering device can meet the requirements of high-speed operation.

Northeast Agricultural University designed and improved a counter-inclined disc seed-metering device<sup>8</sup> on the basis of the tilted disc seeder, as shown in Figure 4, this seed-metering device retains its original small size and structure. At the same time with the advantages of compactness and low cost<sup>9</sup>, the double discs are opposed, the holes are staggered, and the method of sowing a single bar allows the absolute angular velocity of the seed disc inside the seed meter to be doubled, so that seed-metering device can maintain a single very good operation index, so as to meet the requirements of high-speed operation.

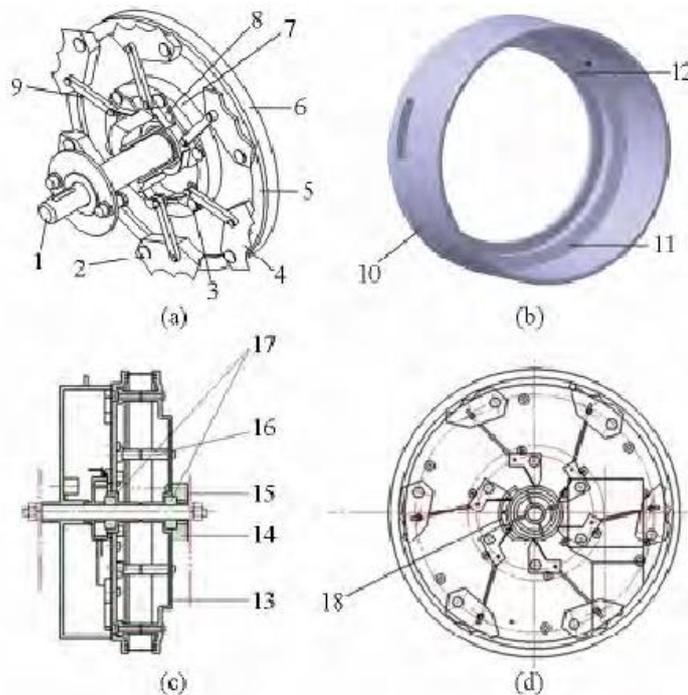
Jia Honglei's team of Jilin University designed a double concave rocker type seed-metering device<sup>10</sup>. As shown in Fig.5, the working parts of the seed-metering device are mainly composed of a seed taking block, a turntable, an inclined seed cleaning ring, and a seed cleaning brush. The seed-metering device utilizes

the double concave curved surface of the seed taking block to retrieve the soybean seeds in the seed filling area, so that a few soybean seeds enter the first concave curved surface to complete the seed filling process. Then use the seed cleaning brush to sweep the excess soybean seeds in the first concave curved surface

into the second concave curved surface, and return to the seed filling area under the action of the inclined seed cleaning ring. Finally, the single grain is discharged out of the seeding port under the combined action of taking seed block blessing force, its own gravity and centrifugal force to complete the seeding.



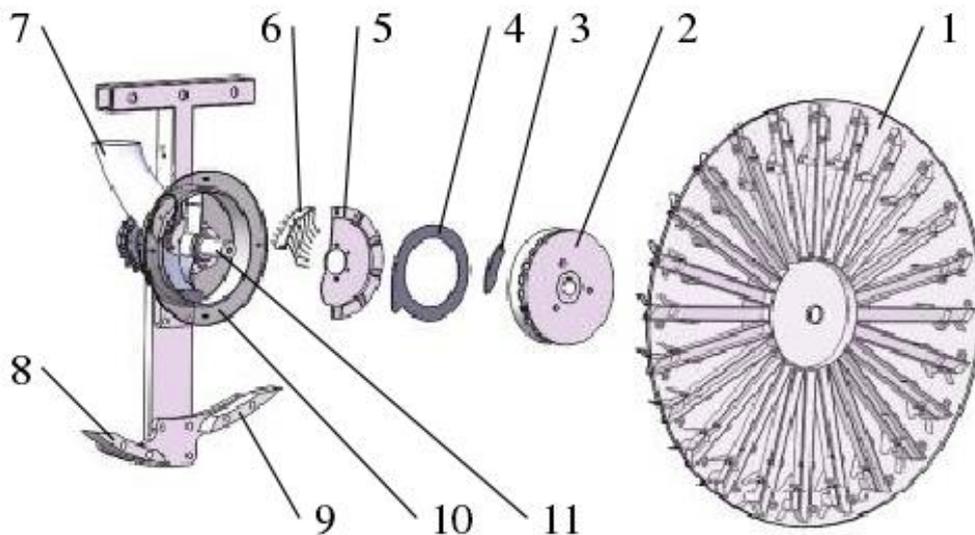
**Figure 4 Counter-inclined disc seed-metering device**



**Figure 5 Double concave rocker type seed-metering device** (a) Structure diagram of seeding turntable (b) Tilt clear ring (c) Side view (d) Main view of seeding device 1. axis 2,3. Screws 4. Double concave curved surface take seed block 5. Take seed block ring 6. Turntable 7. crank arm ring 8. crank and crutch 9. Connecting rod 10. Species box 11. Incline type ring 12. Seed cleaning brush 13. Seed box cover 14. Box 15. Bearing end cover 16. Connecting rod 17. Deep groove ball bearing 18. Cam

Luo Sibao's team at Northeast Agricultural University designed a friction disc type vertical seed-metering device<sup>11</sup>, as shown in Figure 6, the seed meter is mainly composed of combined seed plate, pressure plate, clearing wire, seeding Disk and other components. When the seeding device is working, the seeds enter the seed chamber under the effect of their own gravity, and move together with the seed disc under the action of friction and fill into the mold holes to complete the seed filling process<sup>12</sup>. In the seed cleaning area and the seed protection

area, the seeds have lost the resistance of the pressure plate, and the excess seeds in the hole are returned to the seed room under the action of gravity and the wire for the seed cleaning, completing the seed cleaning and seed protection process. The seeds continue to move in the hole, and when they reach the seed outlet, the seeds lose the protection of the shell and fall into the corresponding seed tube from the seed outlet to complete the seeding process.



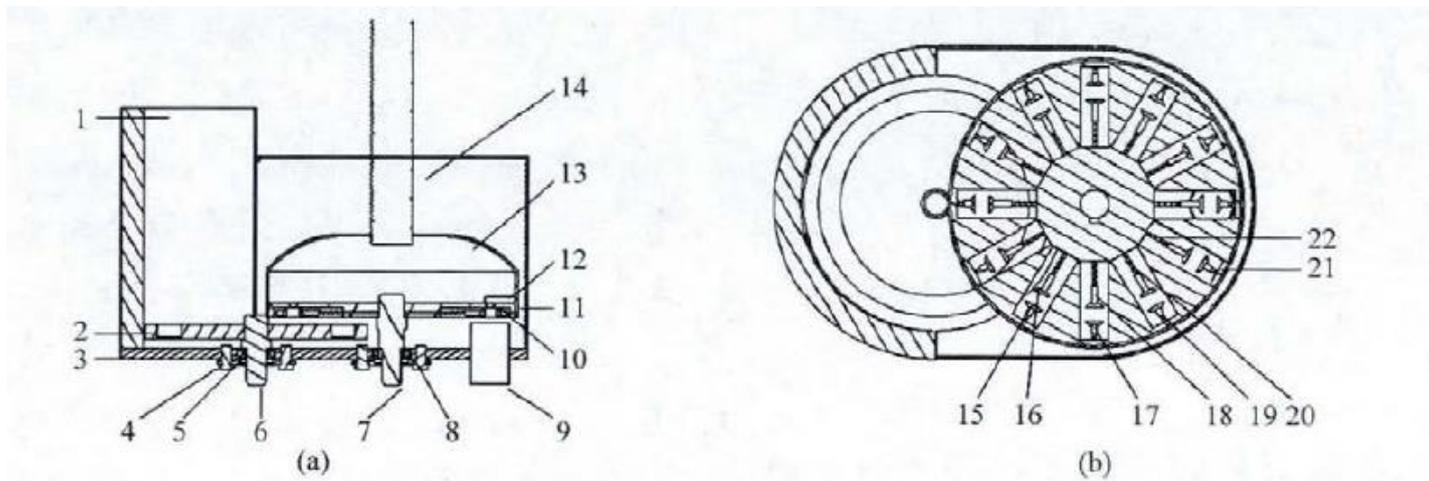
**Figure 6 Friction vertical disc seed-metering device** 1. cast disc 2. combined type plate 4. push seed plate 5. press plate 6. clear steel wire 7. inlet 8. cast cam 9. dwell cam 10. housing (row port) 11. spindle

China began to develop pneumatic seed-metering devices in the early 1980s, and it has also developed rapidly in recent years. Zhao Jiale of Jilin University and others designed a biased double-disc suction seeding device<sup>13</sup>. As shown in Figure 7, the seeding device adopts a combination of mechanical and suction suction design, which is mainly composed of The seed box, the seed disc, the seed suction cup, the spherical symmetric curved surface seed picking clamp, and the cone-shaped seed suction hole are composed of such

structures. When the seed-metering device is working, the seeds in the seed box are first filled into the grooves of the seed disc. When the seeding disc moves below the seeding suction cup, due to the action of the fan, the negative pressure is generated on the upper and lower sides of the seeding suction cup. The seeds in the groove are affected by the suction force and move toward the suction hole. The seeds contacted by the seed hole will be sucked by the seed suction hole, so that the seed suction hole is blocked. There is no gas

flow at the lower end of the blocked seed suction hole, and the remaining seed seeds that are not sucked by the seed suction hole are not Suction again. This ensures that a set of spherical symmetry curved seed collection clamps can only hold one seed<sup>14</sup>. The clamped seeds move with the seeding suction cup. When the seeds move to the position above the seeding tube, the upper end of the suction hole will be blocked by the rubber windshield above the

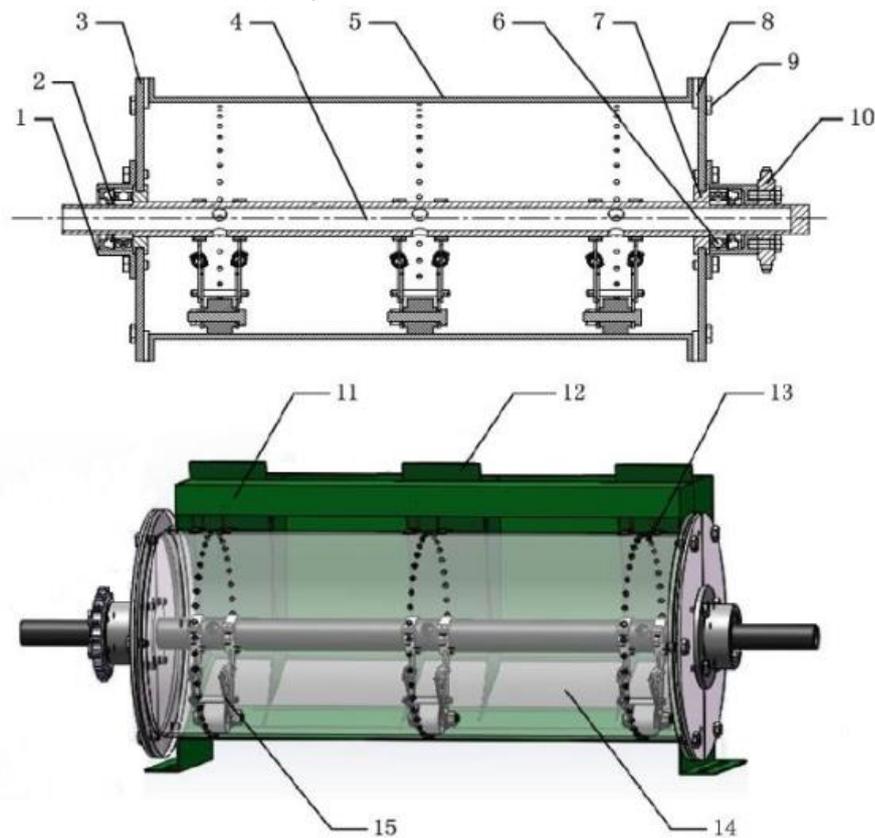
seeding suction cup, and the suction force of the clamped seeds will not be lost. The seeds fall into the seeding tube under the weight of the self-weight and the pressure of the seeding clip to complete the entire seeding process. The seed- metering device combines the advantages of mechanical and air-suction seed metering devices, and has the advantages of low replay rate, low leakage rate, low breakage rate, and high speed operation.



**Figure 7 Bias double disc suction seed-metering device** (a) Main view (b) Top view 1. kind of box 2. Transport disc 3. Seed meter cover 4. bearing end cover 5. seeding disc bearing 6. seeding spindle 7. seeding sucker shaft 8. seeding sucker bearing 9. seeding tube 10. seeding sucker hole 11. seeding sucker 12. rubber windshield 13. airtight bellows 15. spherical symmetrical curved surface sampling clip 17. hollow shaft 19.20. spring 21. solid shaft

Li Tonghui of Northeast Agricultural University designed an air suction drum-type three-row soybean seed-metering device<sup>15</sup>. As shown in Fig. 8, the seed-metering device is mainly composed of a seeding roller assembly, a seed box assembly, a main shaft, a seed cleaning device and a pressure relief device. When the seed-metering device is working, the seeds in the seed group are attracted to the outer wall of the drum by the suction force and move out of the seed group with the drum to complete the seed filling process<sup>16</sup>. Then, the seed will rotate with the drum under the combined action of the adsorption force formed by the pressure difference between the inside and outside of the hole, its own gravity, the centrifugal force

generated by the rotation of the drum, the support force of the drum to the seed, and the friction force. When the seeds continue to rotate to the seed clearing area, the seed clearing piece located in this area scrapes off the excess seeds, so that there is only one seed in each hole, thus completing the seed clearing process. When the seed is transferred to the seeding area, the elastic pressure relief wheel blocks the internal hole, the seed no longer receives the adsorption force and leaves the drum under the effect of its own gravity to complete the seeding process. Compared with the traditional air-suction seed- metering device, the seed metering device has good sealing effect and simple structure.



**Figure 8 Three rows of soybean seeder on air-suction drum ridge** 1. end cap 2. skeleton seal ring 3. side plate 4. spindle 5. Roller 6. Sealing bearings 7. Groove partitions 8. asbestos gasket 9. Bolts 10. Transmission sprocket 11. Type box 12. Type box height adjustment plate 13. Seed cleaning device 14. Discharging plates 15. Elastic relief wheels

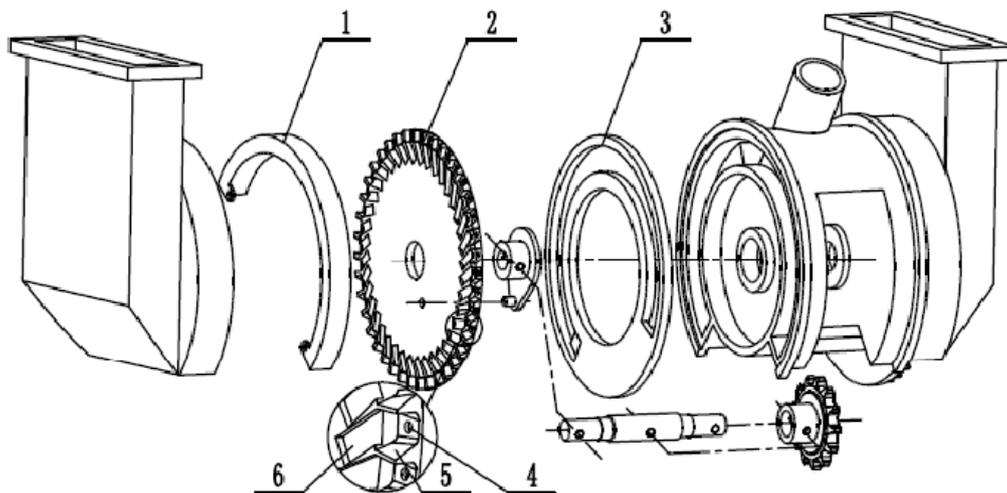
Chen Yulong of Jilin University designed an air-suction mechanical compound seed-metering device<sup>17</sup> for the problem that the air-suction seed-metering device requires high negative pressure during high-speed operation and the negative pressure fluctuation will cause leakage sowing, as shown in Figure 9. The seed-metering device combines an air-suction seeding device and a vertical disc-type seeding device. When the seeding device is working, it is divided into three working modes: air-suction working state, mechanical working state and air-suction mechanical compound working state. status. During mechanical operation, the seeds enter the seed hole through filling, rely on gravity and the seed protection plate for seed cleaning, and rely on the seed transportation channel composed of the seed protection plate and the seed hole to transport the seed. The seed is not protected by the protection plate during seeding. Dropped under the

action of gravity; the seeds are filled under the suction of negative pressure during the suction operation. The seeds are cleaned by gravity and the seeds are transported by negative pressure. When seeding, the airflow is blocked at the seeding position and the negative pressure It disappears, and the seeds come out under the effect of their own gravity. The working process of the composite operation state of the air suction machine is a combined mode of air suction operation and mechanical operation. This seed-metering device requires low negative pressure during high-speed operation and can maintain good seeding performance under the condition of negative pressure instability.

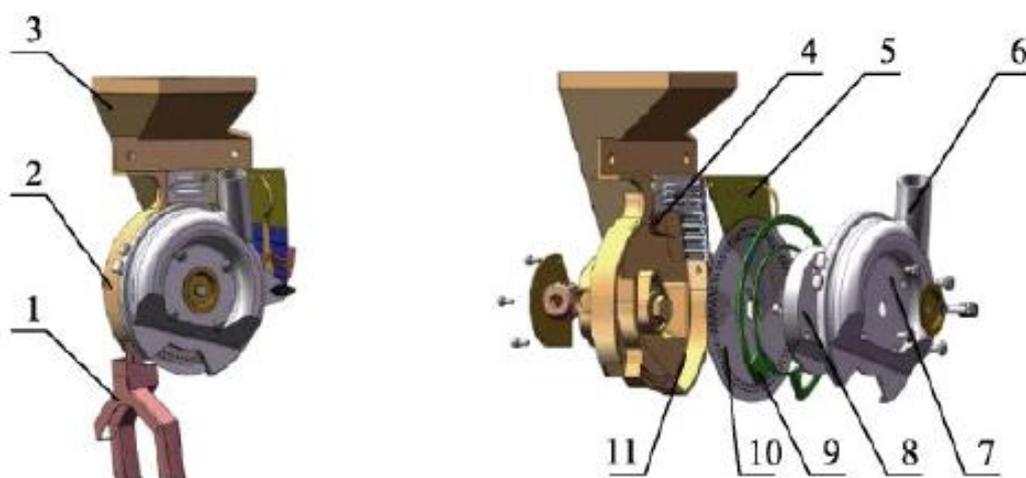
In order to meet the operation requirements of soybean narrow-row dense planting and seeding<sup>18</sup>, Chen Meizhou of Shandong University of Technology designed a single-disc double-row air suction seed-metering device<sup>19</sup>, as shown

in Figure 10, the seed-metering device is mainly composed of It is composed of shell, seed-discharging tray, internal and external seed cleaner. The seeding disc has inner and outer double-ring suction holes, and cooperates with the seeding device under the seeding device to realize double row seeding of a single seeding disc. When the seeding device is working, the seeds are adsorbed on the suction hole of the seeding plate under the action of negative pressure to complete the seeding process. With the movement of the seeding plate, the seeds reach the seed cleaning area. Under the action, the excess seeds are

cleared, and the seeds in the suction hole continue to move to the seeding area with the seeding disc. The suction holes in the inner and outer rings of the seeding disc are blocked, and the negative pressure disappears. The seeds fall into the left and right split tubes of the splitter respectively and then fall into the seed ditch to complete the seeding process. The seed-metering device can realize narrow-row dense planting and seeding, which solves the problems of too large narrow-row dense planting row distance of the traditional soybean planter, difficult to adjust, and poor seeding performance.



**Figure 9 Air-suction mechanical composite seed-metering device** 1. seed protection plate 2. seed row plate 3. air chamber adjustment plate 4. suction hole 5. take seed hole 6. stir seed tank



**Figure 10 Single-disk double-row air suction seed-metering device** 1. seed distributor 2. housing 3. seed storage box 4. outer seed cleaner 5. inner seed cleaner 6. suction tube 7. end cover 8. suction chamber 9. seal 10. seed tray 11. seed chamber

## Development trend of soybean seed-metering device in China

### Development of high performance

With the continuous development of high-power tractors, the seeding speed of the seeder continues to increase, which requires the seed-metering device to develop in the direction of high-speed seeding. On the premise of meeting the seeding requirements such as precision, uniformity and seed emergence rate, Try to increase its working speed. Soybean seeder has evolved from a mechanical type to a pneumatic type. After a long time, the seeding performance of the seed-metering device has made great progress. In order to meet the requirements of seeding, while improving the seed-metering device, its auxiliary equipment also needs to be continuously improved. The design of more reasonable and perfect openers, seed delivery pipes and other related equipment enables the seeds to fall into the seed hole in time according to the expected track and speed after leaving the seed meter<sup>20</sup>.

### Development of new technologies

With the continuous development of intelligent technology, the use of computer vision and image processing technology, detection and control technologies such as electro-optic sensors has become a trend<sup>21-24</sup>. The use of high-speed camera<sup>25</sup> to study the movement trajectory and uniformity of the seed during the seeding process can provide an important basis for the optimization of the working parameters of the seed-metering device. The optical signal<sup>26</sup> is used to observe the rotation of the seeding shaft and displayed with numbers. The broadcast volume and unit broadcast volume of each row provide convenience for the improvement of the seed metering device, so that the seed metering device has higher seeding performance.

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