Design and test of aerial broadcast device for agricultural granular materials

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Abstract: Aerial broadcast refers to the operation mode of broadcasting agricultural granular materials such as seeds, solid fertilizers, and granule fungicide by mounting special broadcast devices on agricultural aircraft. In order to improve the effect of aerial broadcast operations, particle material broadcast devices that are suitable for UAV were explored. An aerial broadcast device for agricultural granular materials with agricultural UAV was designed as the carrying platform in this study. And the broadcast device used corn and mung bean as the particle model to simulate the running state, fixed-point broadcast and mobile broadcast by using EDEM. In addition, an indoor mobile-broadcast experiment was carried out by replacing the flying operation state of the UAV by the movement of the mobile slide way platform. The results of simulation showed that the broadcast device had the best speeds of blade wheel for different agricultural granular materials. When the speeds of corn and mung bean materials were 10 r/min and 15 r/min respectively, the material had a continuous and stable blanking effect in the quantitative unit. At the same time, the best speeds of blade wheel for the corn and mung bean materials measured in the actual test of the broadcast device were 11 r/min and 17 r/min, which were close to the results of simulation. When the broadcast device performed fixed-point broadcasting, the material was distributed in a circular ring radially centered on the device below. And when the speed of projecting disc was slow, the width of broadcast was small and the distribution of material was concentrated; when the speed was fast, the width of broadcast was large and the materials on both sides were symmetrically distributed. Under the slow speed of projecting disc, the distribution pattern of corn and mung beans was high in the middle, low at both ends, and the width of spraying was narrow; Under medium-fast and fast speeds of projecting disc, the corn material was distributed in a “W” shape, the mung bean material was more evenly distributed, and the material distribution coefficient of variation was basically about 20%. It showed that the broadcast device has great broadcasting performance under appropriate parameters, and it can provide reference for subsequent aerial broadcasting research.

Keywords: agricultural aviation; broadcast; granular material; speed of projecting disc; distribution
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1 Introduction

There is a shortage of rural labor in our country because of the development of urbanization. Therefore, as a agricultural country, it is the general trend that our country’s agricultural development will shift from traditional manual operations to mechanization and automation[1]. Compared with manual operation, ground mechanical operation can greatly improve work efficiency, save time and labour force, improve farmers’ economic benefits, and promote production scale. However, ground machinery operation is easy to crush crops to cause certain crop damage when entering field operations, which compact the soil and destroy the soil structure of the farmland; and it has certain requirements on the topography of the operation field, and its applicability is relatively poor[2-4]. With the rapid development of our country’s UAV industry and the concept of precision agriculture aviation, agricultural UAV have come into people's view[5,6].

Aerial broadcast refers to the operation mode of broadcasting agricultural granular materials such as seeds, solid fertilizers, and granule fungicide by mounting special broadcast devices on agricultural aircraft[7,8]. The early domestic platforms of aerial broadcast mainly relied on manned fixed-wing aircraft and helicopters[9]. However, apart from Northeast, Xinjiang and the three major plains in China, there are few large-scale farms in other regions. The arable land is mostly independent blocks, and the per capita arable land is small, especially the gridded and hilly landforms of southern fields are not suitable for manned airplane to sow[10-12]. As agricultural UAVs are small in size, easy to carry,

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flexible in operation, highly automated, and do not require a special take-off runway, they are very suitable for broadcast operations on such terrain[13,14]. Therefore, there is a huge potential market for aerial broadcast operations of agricultural UAV in China[15,16].

At present, the broadcast equipment used for manned fixed-wing aircraft is relatively mature, mostly used for aerial seeding afforestation and aerial seeding of pasture, but the broadcast device specially used for unmanned helicopters has entered the high-speed research and development stage in China in the past two years. In recent years, domestic scientific research institutions and enterprises have conducted relevant research on the technology of broadcast UAV[17,18]. However, although some university scientific research institutions and UAV companies have developed some related broadcast devices or broadcast UAV, the technology has not yet been used on a large scale[19-21]. Therefore, according to the problems of other broadcast devices, such as the application of single broadcasted material, the easy blockage of the quantitative seeding mechanism, the small amount of the broadcast mechanism, and the easy splashing of the broadcasted material onto the UAV body, we have made innovations in the structure design of the broadcast device. We design a low-altitude and high-speed broadcast device mounted on an agricultural UAV in this paper. The broadcast device is suitable for aerial broadcast of agricultural granular materials such as seeds, fertilizers and granular pesticides. And we conducted particle simulation and the verification of test result. This provides a certain reference value for the research and design direction and actual operation of subsequent aerial broadcast equipment, and has certain practical application value.

2 Device design

The overall structure design of the agricultural particle material aerial broadcast device designed in this paper mainly includes three parts: a detachable material box unit, a rotating-blade-wheel quantitative unit, and a centrifugal-disc broadcast unit. The design of the main components is a combination of the functional requirements of the broadcast device and the physical and chemical characteristics of the broadcasted particulate material, the portability of the connection with the UAV, the mechanical design principle, the structural design and the rationality of assembly.

2.1 Demountable material box

As shown in Figure 1, the main body of the material box is divided into two detachable upper and lower parts. The design of the outer dimensions of the upper part of the material box is mainly based on the agricultural UAV model selected for the device. The top of the material box is designed with two in-material ports. Open the cover of the two material boxes, and unload materials to the inlets at the same time, so that the materials are evenly distributed in the material box. The design of the upper part of the material box ensures that there is a larger storage space within the limited design size and a better continuous effect of blanking. The lower part of the material box is used as a quantitative housing of the quantitative unit, which can cooperate with the quantitative blade wheel to form a quantitative unit similar to a closed air conditioner.

2.2 Quantitative blade wheel

As mentioned above, the lower part of the material box serves as the quantitative shell of the quantitative unit, and the quantitative blade wheel and the inner wall of the material box form a quantitative unit similar to a closed air conditioner, as shown in Figure 2.

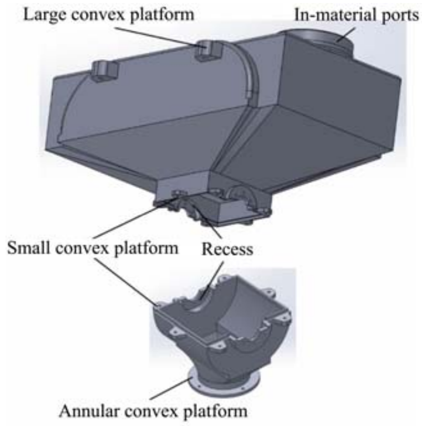


Figure 1 Details of the upper and lower parts of the material box

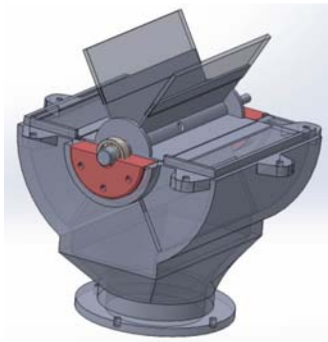
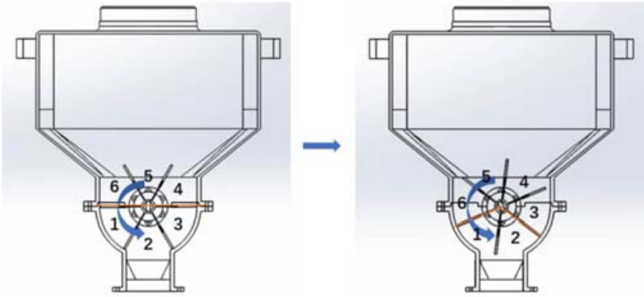


Figure 2 Quantitative unit

The quantitative blade wheel is composed of 6 extending blades radially. The angle between two adjacent blades is 60°. The blade is composed of hard and soft parts. The outer side of the blade is made of soft material, which has good toughness and certain elasticity, so that it is not easy to block when the material falls in the gap between the blade and the inner wall of the quantitative shell. According to the counterclockwise rotation of the fixed blade wheel, we named the small areas divided by the blades 1 to 6 for explanation. As shown in Figure 3a, when a blade rotates to a horizontal state, the two horizontal blades completely separate all materials in area 4, 5, 6 from the upper part of the entire material box. At this time area 1 and 3 are independent closed areas, and only area 2 is connected to the out-materials port in the lower part of the material box, in other words, only the materials in area 2 will be 'fed' to the broadcast unit. When the blade wheel continues to rotate to the position shown in Figure 3b, the blade completely separate all materials in areas 3, 4, 5, and 6 and the upper part of the entire material box. At this time, areas 1, 2 are connected to the out-materials port, in other words, the materials in areas 1 and 2 will be 'fed' to the broadcast unit. Therefore, no matter which angle the quantitative blade wheel rotates, there is always two blades can form a closed area with the inner wall of the material box to separate the material inside the material box from the out-materials port. And at least one and at most two small areas connected to the out-materials port provide material for the broadcast unit. The quantitative unit controls whether the device is blanking and the speed of blanking by controlling the start and stop of the motor or changing the speed of the motor of the quantitative unit.

2.3 Projecting disc components

The projecting disc component is the projecting disc unit of the device, including the projecting disc cover, the projecting disc base, the projecting disc, the projecting disc shaft and the projecting disc tappet, as shown in Figure 4. By rotating the motor and connecting the projecting disc shaft to drive the projecting disc to rotate, the material falling on the projecting disc is thrown out.



a. State 1 b. State 2

Figure 3 Schematic diagram of quantitative principle

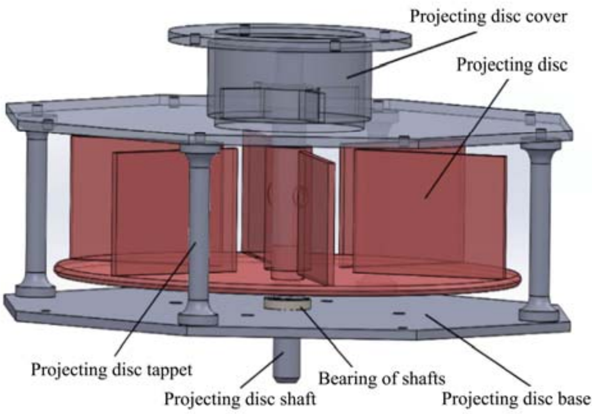


Figure 4 Projecting disc components

2.4 Device control system

The control system of this device includes two DC motors and two remote-control governors. We use the XD-37GB555 micro DC motor for the quantitative unit, which its adjustable speed range is 0-30 r/min and the power is 20W. We use the XD-60GA775 DC motor for the projecting disc unit, which its adjustable speed range is 0-300 r/min and the power is 35W.

The governor is mainly used to control the speed of the motor to control the speed of blanking and projecting disc. Therefore, we choose two wireless remote control DC motor governors with different signal frequency bands, and the fastest control distance can reach 80 m.

This broadcast device is designed with agricultural UAVs as the carrying model, as shown in Figure 5. After the broadcast device is mounted on the UAV, when the UAV starts to travel after taking off to the working height, two governors are used to remotely control the start of the quantitative unit motor and the projecting disc unit motor. The start of the quantitative unit motor drives the rotation of the quantitative blade wheel. When the rational speed of the blade wheel is adjusted to an appropriate value by the remote controler, the blade agitates the material in the material box from the in-materals inlets at the lower part of the material box to the projecting disc unit for continuous and stable ‘feeding’. The projecting disc also starts to rotate with the projecting disc motor turned on, and the particulate material falling on the projecting disc is thrown from the projecting disc by centrifugal motion under the action of the it’s rotation. The device can remotely control the rotational speed of the projecting disc through the governor control the rotational speed of he projecting disc motor. According to the centrifugal force formula, the faster the speed, the greater the centrifugal force, and the particle material will be thrown farther, in other words, the amplitude of spraying is larger.

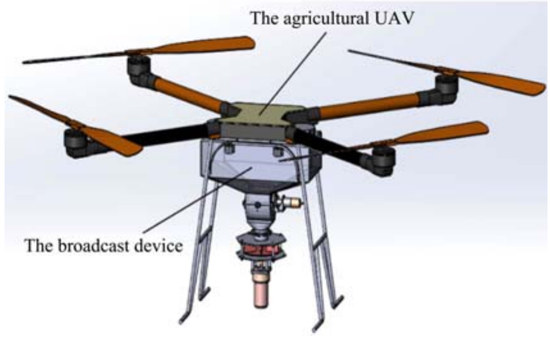


Figure 5 Schematic diagram of the broadcast device mounted on the UAV

3 Simulation analysis

EDEM, a professional particle simulation software, was used as the simulation analysis in this paper, and we choose test materials are corn kernels and mung bean particles. First, a sample is randomly selected from the full and undamaged material particles for mapping; Secondly, the sample model is drawn by Solidworks at a scale of 1:1; Finally, after finishing mapping, we import it into EDEM as the material contour for further construction of the material in EDEM. This simulation can be divided into three parts according to the level from simple to complex.

The first part is the simulation of device operating status. We only change the rotational speed of the fixed blade wheel and the projecting disc to observe. When the device is under different working conditions, we observe whether the device can operate normally and the movement state of the whole process of agricultural granular materials inside the broadcast device and after being thrown out of the device, and analyze the rotational speed of the quantitative unit to ensure the best continuous stable effect of blanking;

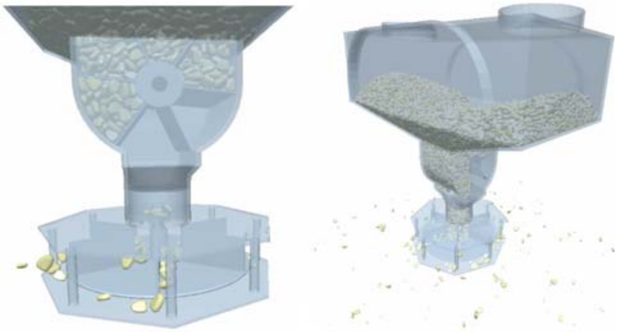
The second part is the simulation of fixed-point broadcasting. On the basis of the first part of the simulation, we analyze the fixed-point broadcasting effect of the broadcast device under the best rotational speed of quantitative unit and different rotational speeds of projecting disc according to the material distribution in the inoculation tray arranged on the ground below after broadcasting;

The third part is the simulation of mobile broadcast. The simulation connects the broadcast device with the mobile slide rail platform trolley to realize the simulation of broadcast during the movement of the device. It can simulate the actual broadcast effect of mobile broadcast and analyze the broadcast effect of the broadcast device under the best rotational speed of quantitative unit and different rotational speeds of projecting disc according to the material distribution in the inoculation tray arranged on the ground.

3.1 Device operating state simulation

The simulation of this part is to simulate the operation of the device under different rotational speeds of blade wheel. The blade wheel of the device is used to shift the granular materials in the material box and realize the quantitative control of blanking under the overall action of the quantitative unit. We chose the slow-speed motor XD-37GB555 , which the adjustable speed range is 0-30 r/min. In this simulation, the rotational speed of the blade wheel was set to 5 r/min, 10 r/min, 15 r/min, 20 r/min, and 30 r/min, and the speed of projecting disc was fixed to 300 r/min to analyse the simulation of 10 sets for the two agricultural particles of corn and mung bean.

By comparing the above 10 sets of simulations of device operating state, it can be found that different speeds of blade wheel have a significant impact on the operating status of the device, and different particulate materials have different optimal speeds. If the speed is too slow, intermittent blanking will occur. That is, when the material in one fan-shaped area completely falls into the projecting disc and is thrown out from it, and the next fan-shaped area has not rotated to connected with the out-material port, a neutral stop will appear in the broadcasting of materials in two adjacent fan-shaped areas. This resulted in an intermittent blanking situation, as shown in Figure 6. However, if the speed is too fast, there will be a situation: when the material in a fan-shaped area has not completely fallen into the projecting disc from the out-material port, the area will be rotated to the closed section on the other side, and which causes the material in the next area are easily accumulated and blocked at the out-material port with the material that has not completely fallen into the projecting disc. By observing the simulated situation of the simulation, we can know that when the rotational speed of the blade wheel of the broadcast device is 10 r/min and 15 r/min for the two agricultural granular materials, corn and mung bean, the simulation runs normally and there is the most continuous and stable effect of material broadcasting. Therefore, we chose these two speeds as the best speed of the blade wheel.



a. Intermittent blanking b. Continuous and stable broadcast

Figure 6 Simulation of broadcast effect

3.2 Device fixed-point broadcast simulation

In the first part of the simulation of the operating state of the device, we knew the best speeds of the blade wheel for the two agricultural granular materials of corn and mung bean. Therefore, we apply the above-mentioned optimal speed to the simulation parameter setting of the second part to study the fixed-point broadcast effect corresponding to different speeds of the projecting disc under the ideal speed of blade wheel.

The geometry of the device used in the simulation of fixed-point broadcast is composed of the simplified broadcast device of the first part and an inoculation plate arranged 3 meters directly below to collect particulate materials. We use solidworks to map a 54 mm×28 mm×4.5 mm 32-hole inoculation tray with a size ratio of 1:1 to simulate the broadcast device hovering at a position 3 m above the ground for fixed-point spraying. The simulation result of the fixed-point broadcasting of the broadcast device is shown in Figure 7.

Comparing and analyzing the distribution of materials in the inoculation trays of the six sets of simulations of fixed-point broadcasting, we found that the distribution law of material broadcasting during fixed-point broadcasting of the broadcast device is a circular radial distribution law. When the rotational speed of the projecting disc is slower, the spray range is smaller and the particle material distribution is more concentrated. With the center of the circle under the device, the particle material distribution law changes in the order of "more→much more→ less → rare → none" and it radiates from the center of the circle. When the rotational speed of the projecting disc is faster, the spray range is larger, and the distribution law of the particle material changes in the order of "much less → less → more →much less → little or no" and it radiates outward from the center of the circle.

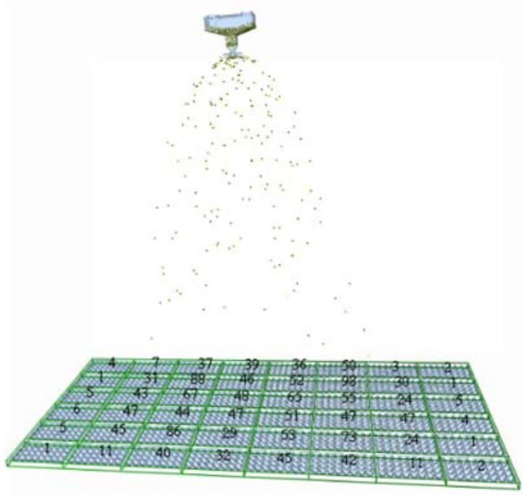


Figure 7 Demonstration diagram of simulation result of fixed-point broadcasting of broadcast device

3.3 Device mobile broadcast simulation

When the broadcast device is in actual work, it is carried on the agricultural UAV for mobile broadcasting operations. Therefore, to test the broadcast effect of the device, we also need to simulate the mobile broadcast of the device. The simulation in this part is to simulate the mobile broadcast of the device under the condition of a uniform linear motion on a 12-meter-long mobile slide rail platform. In the simulation of this part, the speed of blade wheel is set to the corresponding value of optimal speed and the speed of projecting disc is fixed to 180 r/min, and we make a set of simulations for two agricultural granular materials that is corn and mung bean respectively.

From the simulation results of the corn's broadcasting, it can be seen that the material distribution rules in the fourth and fifth rows in the middle section of the material tray are very similar. This is mainly because the particulate material in the device is not completely generated, and the device's blade wheel and projecting disc have not yet begun to rotate, but the device has begun to move forward, resulting in the first few rows in an abnormal broadcasting section. The distribution rule of the last line is different from the distribution rule of these two stable broadcasting sections, because the last line is close to the end of the slide rail, and there is still a part of the material that should have fallen into it at the end of the simulation. Therefore, we take the stable broadcasting section of the corn material mobile broadcasting simulation to analyze the material distribution law, remove the first and last two rows in the invalid spray range, and analyze the material distribution in the middle 8 rows of inoculation trays, as shown in Figure 8. It can be seen from the figure that the material distribution in the simulation experiment of corn's mobile broadcasting is "W"-shaped; at the same time, the coefficient of variation CV can be obtained as 41.15% and 33.38% for the material distribution in the stable broadcasting section.

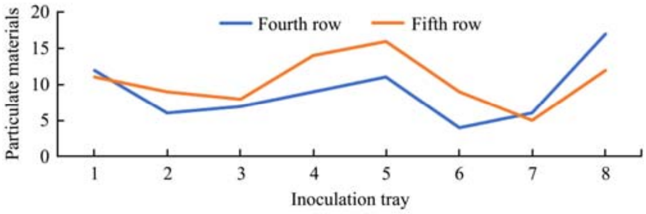


Figure 8 The distribution of the corn's broadcasting simulation

Similarly, we analyzed the results of the mung bean's broadcasting simulation. Different from the corn experiment, in the mung bean's mobile broadcasting simulation experiment, the three rows of inoculation plates were arranged in the middle section of the slide rail platform at an interval of 1.5 m. We removed the first and last two columns of the inoculation tray, and analyzed the material distribution rules of the three rows of inoculation trays, as shown in Figure 9. It can be seen from the figure that the material distribution in the simulation test of mung bean's mobile broadcasting is wavy, with more ups and downs but not much fluctuation, and more uniform. The coefficient of variation of the material distribution of the three rows of inoculation plates was 16.29%, 23.72% and 24.07%.

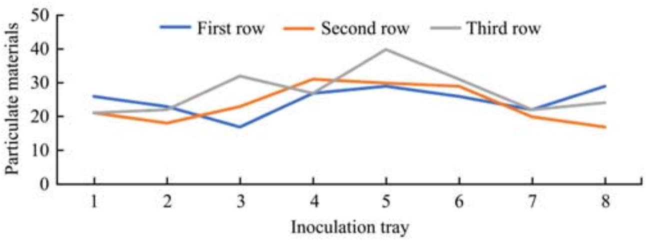


Figure 9 The distribution of mung bean's broadcasting simulation

4 Test and analysis

4.1 Materials and Methods

In this paper, a mobile broadcasting test of the broadcast device on a mobile slide rail platform is designed. The broadcast device is set up on a mobile slide rail to simulate the flight of a UAV. We performed the broadcasting uniformity test of corn and mung bean particles under different rotational speeds of projecting disc.

The mobile slide rail platform used in the test is composed of a slide rail frame and a rail car. The slide rail is 12 meters long and 3 meters high, which is constructed of aluminum alloy materials. Figure 10 shows the structure of the mobile slide rail platform. When the mobile slide rail platform is working, the broadcast device is mounted on the track trolley, and the forward movement of the track trolley drives the broadcast device to carry out the broadcast operation in the mobile state.

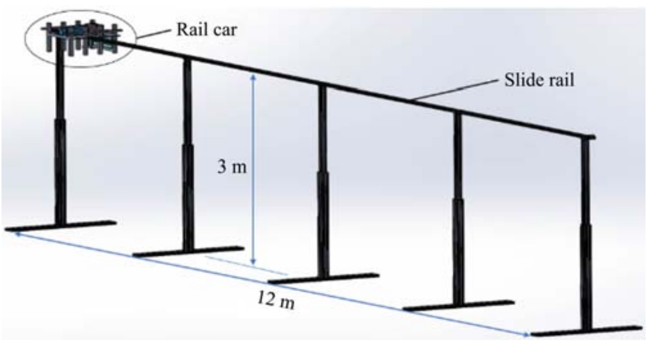


Figure 10 Schematic diagram of the structure of the mobile slide rail platform

We set up a total of 6 sets of experiments for two materials of corn and mung bean, and analyze the two materials for the mobile broadcast effect of the broadcast device under the three different rotational speed gradients of slow, medium and fast under the corresponding optimal speed of blade wheel. We set the parameters of the microcomputer controller so that the moving speed of the broadcast device and the trolley were 1 m/s, and three rows of seedling trays filled with soil were arranged on the ground under the stable broadcasting section, which is the middle section of the slide rail measured in the simulation part. Each row is separated by 1.5 meters, and each row is placed with 8 seedling trays, as shown in Figure 11. After the track trolley started, the broadcast device was turned on to carry out the broadcast operation, and the broadcasting is stopped after the trolley reaches the end of the track, and we counted the granular materials in the seedling tray. Among them, by changing the rotational speed settings of the two moving components of the blade wheel and the projecting disc, the parameter settings of different groups of tests can be changed.

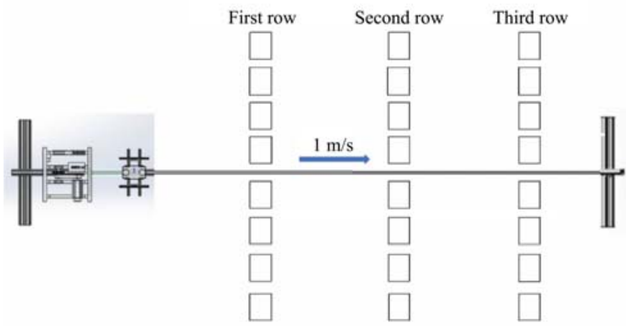


Figure 11 Schematic diagram of test layout

We perform a pre-test on the device's operating status. The granular materials were put into the material box, and the start-stop and the speed of the two motors were respectively controlled by two remote-control governors to observe whether the device was operating normally; whether the process of throwing out the material can be kept continuous and stable. To verify whether the optimal speeds of blade wheel corresponding to the corn and mung bean are the same as the analysis of simulation. However, there is two verification results: when the governor of quantitative unit motor is set to gear 3, corn's broadcasting is the most continuous and stable; when it is set to 5 gears, mung bean's broadcasting is the most continuous and stable. We use the photoelectric tachometer to test the speed of the blade wheel: when the speed controller of quantitative unit is set to 3 gears, the load speed of the blade wheel is about 11 r/min; when it is set to 5 gears, the load speed of the blade wheel is about 17 r/min, which is similar to the simulation result of the first part. In addition, the speed test of the priojecting disc was carried out, and the loading rotational speed of the projecting disc corresponding to the 8 gears of the governor of the priojecting disc unit was measured as follows: 35 r/min, 75 r/min, 110 r/min, 145 r/min, 180 r/min, 215 r/min, 248 r/min, 285 r/min. Therefore, according to the principle of approximation to set the speed gradiently during the simulation, we chose 75 r/min, 180r/min and 285 r/min corresponding to gears 2, 5 and 8 as the slow, medium and fast three gradients of the speeds in this test; as shown in Table 1, 6 groups of trials with trial numbers 1 to 6 are carried out.

Three rows of seedling trays with a size of 54 mm×28 mm are arranged under the slide rail platform with an interval of 1.5 m. Part of the soil is added to the seedling tray to reduce the rebound of materials. The layout of seedling tray is shown in Figure 12.

Table 1 Experimental design

No	Type	Speed of blade wheel/r·min^{-1}	Speed of projecting disc/r·min^{-1}
1	Corn	11	75
2	Corn	11	180
3	Corn	11	285
4	Mung bean	17	75
5	Mung bean	17	180
6	Mung bean	17	285

Figure 12 Schematic diagram of the layout of the seedling tray for the sowing test

4.2 Results and analysis

The data records of the above six groups of experiments are shown in Table 2 and Table 3. The data recorded in the table is the number of materials in each seedling tray.

Table 2 Test results of corn's broadcasting

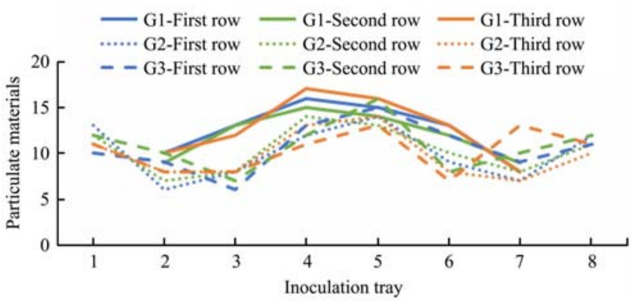
Group	Lines	Row 1	Row 2	Row 3	Row 4	Row 5	Row 6	Row 7	Row 8
1	Line 1	2	10	13	16	15	13	8	1
	Line 2	1	9	13	15	14	12	9	0
	Line 3	1	10	12	17	16	13	8	2
2	Line 1	13	6	8	12	14	9	7	12
	Line 2	12	7	8	14	13	10	8	11
	Line 3	11	8	8	13	14	8	7	10
3	Line 1	10	9	6	13	15	12	9	11
	Line 2	12	10	7	12	16	8	10	12
	Line 3	11	8	8	11	13	7	13	11

Table 3 Test results of mung bean's broadcasting

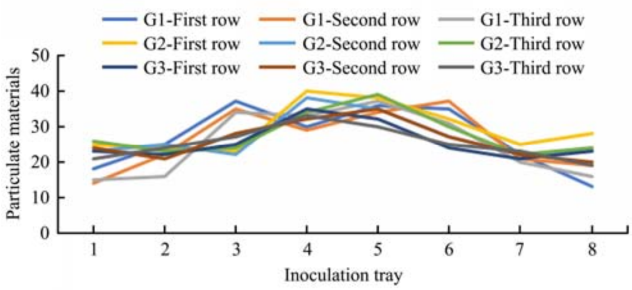
Group	Lines	Row 1	Row 2	Row 3	Row 4	Row 5	Row 6	Row 7	Row 8
1	Line 1	18	25	37	30	36	35	22	13
	Line 2	14	22	35	29	34	37	21	19
	Line 3	15	16	34	33	37	31	20	16
2	Line 1	25	24	23	40	38	32	25	28
	Line 2	23	25	22	38	35	27	22	23
	Line 3	26	23	24	34	39	30	22	24
3	Line 1	23	22	25	35	32	24	21	23
	Line 2	24	21	28	32	35	27	22	20
	Line 3	21	24	27	33	30	25	23	19

It can be found from the table that when the projecting disc's speed level is slow (75 r/min), the material in the first and last two rows of seedling plates of the three rows of seedling plates arranged under the movable slide platform are significantly lower than the middle columns. Especially the first and last two columns of corn material test group 1 are obviously outside the effective spray range. Therefore, the two columns of data in this group are discarded when studying the distribution of materials. The data recorded by the six groups of experiments are drawn with a broken line statistical chart, as shown in Figure 13. We analyze the material distribution law of the broadcast device in the vertical direction of travel according to this.

The graphs of the 6 groups of tests can visually show that when the broadcast device is in mobile broadcasting, the material distribution on both sides of the device is relatively symmetrical. And when the rotational speed is slow, the distribution law of the two materials, corn and mung bean, is high in the middle, low at both ends, and the spray range is narrow. The number of corn materials distributed in the same unit area is less than that of mung bean particles. The reason may be that the volume of corn particles is larger than that of mung bean particles, and the blade wheel speed of the quantitative unit set in the corn material test is slower than that of the mung bean material test. As a result, the amount of material falling into the projecting disc through the feed opening per unit time is less, resulting in a smaller number of corn materials per unit area than mung bean materials. In addition, under the medium and fast speeds, the broadcasting distribution of the corn material is "W"-shaped, that is, three wave crests and two wave troughs are regularly distributed. The distribution of the mung bean material is relatively even, which is the same as the simulation analysis result of mobile broadcasting.



a. Corn test



b. Mung bean test

Figure 13 Distribution of test materials for mobile broadcasting

The coefficient of variation calculated for the results of these six groups is shown in Table 4, that means that the average value obtained is the average coefficient of variation of three repeated groups in each group of tests. Synthesizing the broken line statistics and the calculated coefficient of variation, it can be seen that when the device is at a working height of 3 m, a moving speed of 1 m. And when the blade wheel of the device is at the corresponding optimal speed and the corn and mung bean materials are at the medium and high speeds, there will be a more uniform broadcasting effect, especially for mung bean materials. However, the width of broadcasting is narrower under the slow rotational speed of projecting disc, and there is less material or even no blanking in the seedling plate on both sides. So the coefficient of variation is relatively large, but the distribution is relatively even within the range of the middle six rows of seedling trays (the broadcasting width is about 4.25 m). Therefore, it shows that the broadcast device designed in this paper has better broadcasting performance under suitable working conditions and can meet the actual operation requirements.

Table 4 Variation coefficient of distribution of 6 groups of mobile broadcast test materials

	Corn set 1	Corn set 2	Corn set 3	Mung bean set 1	Mung bean set 2	Mung bean set 3
Line 1	24.13%	29.60%	26.11%	33.12%	22.43%	19.78%
Line 2	21.08%	24.67%	25.75%	32.30%	23.15%	20.61%
Line 3	27.20%	26.21%	22.58%	37.02%	21.86%	18.30%
Average	24.14%	26.83%	24.81%	34.15%	22.48%	19.56%

5 Conclusion

Aiming at aerial broadcasting operations, we designed an aerial broadcast device for agricultural granular materials, and simulate the operation status of the broadcast device by EDEM. At the same time, a mobile broadcasting test of the prototype of the broadcast device was carried out on the mobile slide rail platform to analyze the operation stability and broadcasting performance of the device. We have the following conclusions:

1) When the optimal speeds for corn and mung bean materials are 10 r/min and 15 r/min by EDEM respectively. At the same time, the best speeds of blade wheel for the corn and mung bean measured by the actual test of the broadcast device are 11 r/min and 17 r/min, which are close to the result of simulation. There is a continuous and stable blanking effect of the material in the quantitative unit.

2) When the rotational speed of the projecting disc is slow, the spray range is smaller; when the rotational speed of the projecting disc is faster, the spray range becomes larger, and the distribution of the particulate material is more concentrated, and the changing distribution law of the particulate material gradually decreases from the center of the circle outward.

3) Through the analysis of the simulation and actual broadcasting test, it can be found that when the broadcast device is at the best speed of blade wheel, it has good broadcasting uniformity for corn and mung bean, and the coefficient of variation is about 20%. In particular, the average coefficient of variation of the material distribution between the entire row of mung bean is 19.56% at a broadcast speed of 300 r/min. It shows that the broadcast device has better broadcasting performance under suitable working conditions, and is suitable for agricultural granular materials of different shapes and sizes.

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