Development of UAV-based shot seeding device for rice planting

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Abstract: In order to realize the high-quality row seeding operation with unmanned aerial vehicle (UAV) in paddy field, a shot seeding device that can sow five rows of pelleted rice seeds at the same time was designed. The shot seeding device mainly consists of an external grooved wheel seed metering device and five shot seeding modules. The designed external grooved wheel seed metering device can take the seeds out of the seed box and divide the seeds into five parts. The shot seeding module can accelerate the pelleted rice seeds to reduce the impact of the UAV wind on the direction of seed movement. Furthermore, an angle adjustment mechanism for the shot seeding module was used to change the row spacing. The seed metering device test verified that when the speed of the seed metering wheel was 15 r/min, the coefficient of variation of the discharge rate of each row ($C.V_1$) and total seed discharge rate stability ($C.V_2$) were 1.70% and 1.04%, respectively. Image processing technique was used to test the UAV seeding performance. The distribution characteristics of seeds on the ground showed that the number of seeds in each row gradually increased from both sides to the middle in the width direction. According to the statistics, there were 60%-70% of the seeds in each row in the 100 mm width range. The field test showed that when the working height was 1.5 m and the seeding quantity was 38.56 kg/hm^2, the performance of sowing in rows was obvious, the deviation rate of seeding quantity was 1.89%. After 16 d of sowing, the seeds' emergence rate was stable, and the average emergence rate was 82.63% and the yield was 6775.50 kg/hm^2.

Keywords: unmanned aerial vehicle, rice direct seeding, row seeding, pelleted rice seeds
DOI: 10.25165/j.ijabe.20221506.7301

Citation: Liu W, Zou S S, Xu X L, Gu Q Y, He W Z, Huang J, et al. Development of UAV-based shot seeding device for rice planting. Int J Agric & Biol Eng, 2022; 15(6): 1–7.

1 Introduction

As an effortless and convenient seeding method, rice direct seeding has received extensive attention in recent years[1,2]. The level of mechanized rice direct seeding in China has been improving year by year[3]. In addition, with the development of agricultural unmanned aerial vehicle (UAV), UAV seeding of rice has become an emerging operation method[4-6]. Compared with ground seeding machinery, UAV seeding has the advantages of flexibility, high efficiency and labor saving[7,8]. But most seeding UAVs are more used in broadcast seeding, and the uniformity of the sowing seeds is not as good as that of the row seeding[9,10]. Research shows, broadcast seeding is more prone to uneven growth density of rice seedlings, which will lead to poor ventilation and be susceptible to lodging[11]. Row seeding can improve the uniformity of seeds, which can overcome the shortcomings of broadcast seeding[12]. Therefore, this paper used the pelleted seeds as the seeding object, and designed a seeding device suitable for UAV operations, which can achieve the row seeding.

At present, some scientific research institutions and companies have carried out relevant researches on UAV seeding. Wu et al.[13] designed a centrifugal rice broadcast seeding, determined the optimal working parameters through simulation tests, and further verified the feasibility of the broadcast seeding device through bench tests and field tests. Song et al.[14-16] conducted research on broadcast seeding UAVs, and designed two broadcast seeding devices, one was centrifugal disc-type, the other was pneumatic-type. Centrifugal disc-type seeding device relied on

Received date: 2021-12-28 **Accepted date:** 2022-05-21
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centrifugal force to spread the seeds, and the pneumatic-type seeding device relied on airflow of the fan to blow the seeds out from different directions, which improved the uniformity of the broadcast seeding. Some UAV companies have also released a variety of models of seeding UAVs, most of which used centrifugal disc or pneumatic broadcast seeding systems, which cannot achieve row seeding operations[17,18]. In order to realize UAV-based row seeding, Huang et al.[19] designed and tested an auxiliary seeding device based on a centrifugal rape seeding device. The seeding row width can reach 6-7 cm, but the whole machine the structure was huge, and the end of the seed guide device was 20 cm away from the ground, which posed a large flight security risk. Yuren UAV (Zhuhai) Co., Ltd. designed a blowing type precision seeding UAV that used high-speed airflow to send seeds to the ground along the pipeline. But when the working height exceeded 50 cm, the seed drifts seriously and the seed rows were not obvious[20]. The Li's research team of China Agricultural University carried out research on non-contact seeding of wheat, accelerating wheat seeds and shooting them into the soil, and designed a device to jet seeds into the soil through high-pressure airflow[21-24]. In addition, researches have also been carried out on the use of centrifugal force to accelerate seeds. But both methods were aimed at ground machinery and were not suitable for UAV rice seeding.

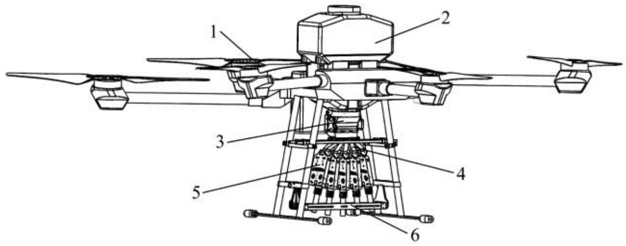
The above researches on UAV seeding had the following shortcomings: (1) Part of the researches only improved the uniformity of the broadcast seeding, but still cannot realize sowing in rows; (2) For reducing the influence of UAV wind on seeding accuracy, the seed outlet was closer to the ground, which posed a greater safety hazard; (3) In order to achieve multi-row seeding, the size of the whole machine was large, which was not convenient for transportation; (4) The seed acceleration ability was limited or the structure was not suitable for UAV row seeding. In order to overcome the above problems, this research designed a new type of shot seeding device for rice that can be carried on a UAV. The device accelerated the pelleted rice seeds through two counter-rotating friction wheels. The whole machine adopted a compact structure to realize the simultaneous sowing in five rows parallel to flight route, even if the working height of the UAV is above 1 m, it still had an obvious line effect.

2 Materials and methods

2.1 Structure design of the seeding device and working principle

The study used the existing UAV (AGRS T16, Shenzhen DJI Technology Co., Ltd.) as a carrier, and designed a new shot seeding device for rice. The structure of the seeding device is shown in Figure 1. It is mainly composed of T16 UAV, seed box, seed metering device, seed distributor, shot seeding module and angle adjustment mechanism. The five shot seeding modules were arranged on a fan-shaped surface which can achieve five-line simultaneous seeding for each route. During operation, the seeds from the seed box passed through the seed metering device, the seed distributor and the shot seeding modules in sequence. The shot seeding module used two high-speed rotating friction wheels to accelerate the seeds to weaken the influence of wind field on seed movement[25,26].

Pelletized rice seeds were used in the UAV seeding operation. Seed pelletizing was a kind of seed coating technology[27]. The seed was wrapped with a special powder, which significantly increased the size and weight of the seed[28,29]. The pelleted rice seeds had better fluidity and strength, which was beneficial to the seed acceleration by the friction wheel and effectively reduced the rate of injury seeds. In this study, the diameter of the pelletized seeds was between 4 mm and 5 mm, the length was in the range of 9 mm to 11 mm.

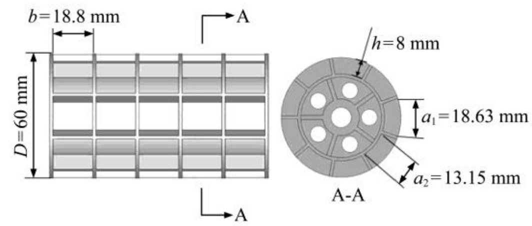


1. UAV platform 2. Seed box 3. Seed-metering device 4. Seed distributor 5. Shot seeding module 6. Angle adjustment mechanism

Figure 1 Shot seeding device

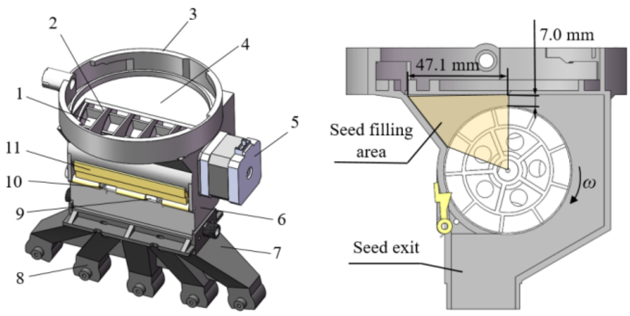
2.1.1 Seed metering device

In this study, the external grooved wheel seed metering device was used to transport the seeds to shot seeding module from the seed box. This kind of seed metering device has simple structure and good working stability, and can be used for pelleted rice seeds. According to the design requirements of five-line simultaneous seeding, the seed metering wheel was designed adaptively at first as shown in Figure 2a. For achieving precise metering, the seed metering wheel was evenly divided into five parts along the axial direction and nine chambers evenly distributed around the outer circle at each part. In order to ensure that the seeds were easy to enter and exit the chamber, the size of the chamber was designed based on the size of the seed. Therefore, according to the range of seed length and diameter in this study, the dimension parameters of the seed metering wheel are indicated in Figure 2a.



Note: D is the diameter of seed metering wheel, mm; b is the width of seed metering wheel chamber, mm; h is the depth of seed metering wheel chamber, mm; a_1 is the top length of seed metering wheel chamber, mm; a_2 is the bottom length of seed metering wheel chamber, mm

a. Seed metering wheel



1. Seed metering wheel 2. Division plate 3. Seed box interface 4. Seed baffle 5. Motor 6. Seed metering device shell 7. Seed distributor 8. Seed outlet 9. Shaft 10. Torsion spring 11. Movable baffle

b. Seed metering device and internal structure

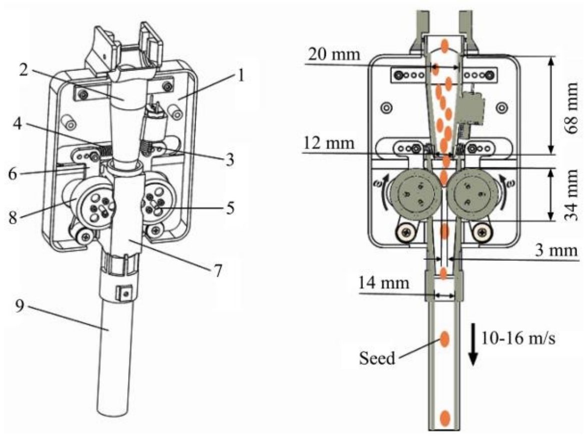
Figure 2 Seed metering device

The overall structure of the seed metering device was designed based on the structure parameters of the seed metering wheel, as shown in Figure 2b. Corresponding to the seed metering wheel, the four division plates evenly divided the interior of the seed metering device shell into five parts, so that the seeds can be separated when they enter the seed metering device. When working, with the rotation of the metering wheel in the ω direction, seeds were transported from seed filling area to seed exit, and discharged from five seed outlets of the seed distributor. There is a 5.3 mm gap between the seed metering wheel and the seed baffle, which can prevent the seed metering wheel from being stuck by the seeds. Besides, the seeds were discharged in the upper part of the seed metering device which can avoid seeds leakage caused by vibration.

2.1.2 Shot seeding module

The shot seeding module was used to accelerate the seeds, and its structure is shown in Figure 3a. The whole module can be divided into two parts according to function: (1) Seed vibration queue device, which consisted of a cone and a vibration motor. It can guide the seeds to enter the friction wheel acceleration device and prevent the seeds from jamming in the cone; (2) Friction wheel acceleration device. The two friction wheels with a diameter of 34 mm were symmetrically distributed on both sides of the acceleration tube, and were partially embedded in it; The friction wheel was installed on the outer rotor of the acceleration motor, and the acceleration motor was installed on the movable motor base; The top of the two movable bases were connected by tension spring, and the bottom were hinged on the mounting plate. The gap between the two friction wheels was set to 3 mm to ensure that the seeds are in contact with the friction wheels. The guide tube was installed at the bottom of the accelerating tube. The main structural parameters of the shot seeding module are shown in Figure 3b.

The acceleration motor adopted an external rotor brushless motor, the motor model was DJI2008-1400KV (Shenzhen DJI Technology Co., Ltd., Shenzhen, China), the motor diameter was 24 mm, the weight was 23 g, and the maximum speed can reach 14 000 r/min. The elastic wrapping material of the friction wheels were polyurethane (PU) and the shore hardness was 60 A.



a. Axonometric drawing b. Sectional drawing

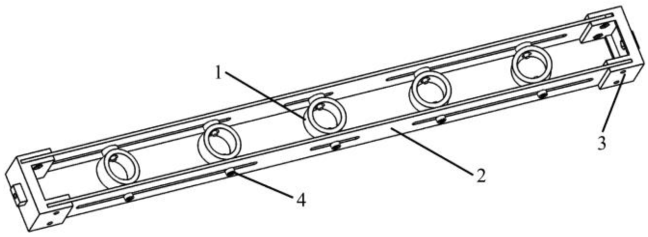
1. Mounting plate 2. Cone 3. Vibration motor 4. Tension spring 5. Acceleration motor 6. Movable motor base 7. Acceleration tube 8. Friction wheel 9. Guide tube

Figure 3 Shot seeding module

When working, the directions of rotation of the two friction wheels are shown in Figure 3b. When the seed enters the friction wheel gap, the friction wheel will speed up the seed, and seed will push two friction wheels to the side. After the seed passed, the friction wheels return to their original position under the action of the tension spring. The structure can accelerate the seeds whose size changes within a certain range, effectively reduce the seed damage rate, and can slow down the surface abrasion of the friction wheel.

2.1.3 Angle adjustment mechanism

The angle adjustment mechanism was used to adjust seeding row spacing in accordance with the working height of the UAV. Figure 4 was the structural diagram of the angle adjustment mechanism, which was composed of a plurality of angle adjustment rings, splint, splint fastener and fastening bolt. Two splints and their fastener formed a rectangular frame, which is fixed on the UAV's body. When the fastening bolts are relaxed, the five angle adjustment rings can rotate around the fastening bolts and slide between the clamping plates. With reference to Figure 1, the angle adjustment ring was sleeved on the guide tube, and the shot seeding module were hinged on the seed distributor. Therefore, the shooting direction can be changed by adjusting the position of the angle adjustment rings.



1. Angle adjustment ring 2. Splint 3. Splint fastener 4. Fastening bolt

Figure 4 Angle adjustment mechanism

2.2 Experiments of seed metering and shot seeding

2.2.1 Seed metering device stability test

The test device is shown in Figure 5. Before the test, filled the seed box with clean seeds, and used seed collection bags to collect the discharged seeds. The test of the seed metering device consisted of the following two parts:

(1) The seed discharging rate under different rotating speeds of the seed metering wheel. In this test, the rotation speed range of the seed metering wheel was 14-20 r/min. After setting the rotation speed of the seed metering wheel, the seed metering device ran for 30 s and weighed the total weight of the seeds discharged from the five outlets. The measurement was repeated three times at each speed level and calculated the average seed discharge rate.

(2) The stability of the seed discharging rate. According to the description of the stability of the seed metering device in the standard GB/T 9478-2005 (Testing methods of sowing in lines), the coefficient of variation of the discharge rate of each row ($C.V_1$) and total seed discharge rate stability ($C.V_2$) were computed. Under the condition that the seed metering wheel was 15 r/min and the running time was 30 s, the weight of the seed discharged by the seed metering device was counted. The measurement was repeated five times and according to Equations (1) and (2) to calculate the $C.V_1$ and $C.V_2$.

$$S = \sqrt{\frac{1}{n-1}\sum(x_i - \bar{x})^2} \quad (1)$$

$$C.V = \frac{S}{\bar{x}} \times 100\% \quad (2)$$

where, in the calculation of $C.V_1$, S is the standard deviation of the weight of seeds discharged in five rows; n is the number of rows, n=5; x_i is the average weight of the five repeated tests in the row i, g; $\bar{x}$ is the average value of x_i, g. In the calculation of $C.V_2$, S is the standard deviation of the total weight of seeds discharged in five tests; n is the number of tests, n=5; x_i is the total weight of seeds discharged from 5 rows in test i, g; $\bar{x}$ the average value of the x_i, g.

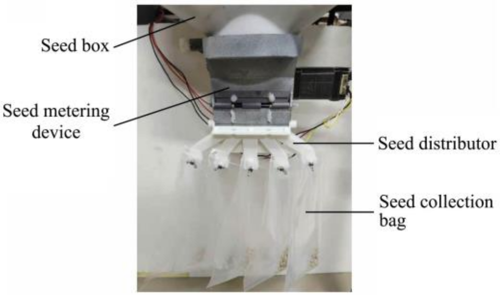


Figure 5 Seed metering device test

2.2.2 UAV seeding performance and field test

Take the AGRS T16 UAV (Shenzhen DJI Technology Co., Ltd.) as a carrier to build a test prototype, as shown in Figure 6. The main technical parameters are shown in Table 1.

Figure 6 Shot seeding UAV

Table 1 Operation parameters of shot seeding UAV

Working height/m	Flying speed/km h^{-1}	Row spacing /cm	Single row seed discharge rate/g s^{-1}	Sowing speed /hm^2 h^{-1}
0.5-2.0	3.6-10.8	15.0-30.0	3.0-5.0	0.6-1.5

(1) UAV seeding performance test

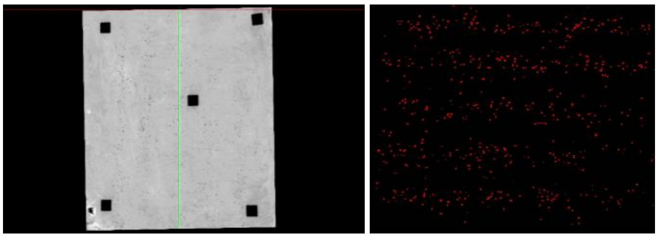
In order to obtain the distribution characteristics of the seeds, a UAV seeding test was carried out above the self-made mud trough (2.5 m×2.0 m, 5 cm in depth). The test site is shown in Figure 7a. The image recognition method was used to obtain the position coordinates of each seed, so as to digitize the position of the seed. The working height of the UAV was 1.5 m, the flying speed was 3.6 km/h, the speed of the friction wheel was 8000 r/min, and the speed of the metering wheel was 15 r/min. The test was repeated three times. Take pictures at a height of 3 m from the mud trough under natural lighting conditions, and the resolution of the collected color image was 2250×4000, as shown in Figure 7b.

a. Sowing in the mud trough

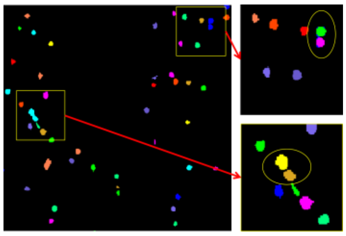
b. Original image of seed trajectory

Figure 7 Experiment of UAV seeding performance

In this study, HALCON 20.11 (MVTec Software GmbH, Munich, Germany) was used for image processing. After dividing the image into R-G-B three channels, the enhanced red channel and blue channel were used for subtraction to gray and enhance the soil area, and then selected the area with the largest area to obtain the image processing region of interest (ROI). Use the center line of the seed row as the vertical *Y* axis to correct the direction of the image and establish an *X*-*Y* coordinate system. The result is shown in Figure 8a. In order to accurately obtain the position of each seed, the image of the region of interest was enhanced with the seed region, as shown in Figure 8b, and the adhesion seeds regions were segmented, as shown in Figure 8c. During the image acquisition process, the actual length represented by each pixel in the image may be uneven in the entire image due to the distortion of the camera. Therefore, according to the five calibration plates (the size of the black grid: 40 mm×40 mm) in Figure 7b, the actual distance represented by each pixel in different areas of the image was calculated respectively. According to the coordinates of the seed pixel and the actual size of the pixel, the actual position coordinates of the seed can be calculated.



a. ROI image after orientation correction b. ROI recognition result



c. Seeds segmentation result

Figure 8 Seed recognition and segmentation

(2) Field test

Field seeding test was carried out on May 21, 2021, at the Zengcheng Teaching and Research Bases, South China Agricultural University. According to the agronomic requirements of direct seeding of rice, completed the field rotary tillage, beating and leveling operations before planting. After the route planning was completed, the shot seeding operation was carried out in the autonomous flight mode, and the actual operation area was 0.252 hm^2. The seeding scene is shown in Figure 9a.

In this test, the rice variety was 19 Xiang, and the thousand-grain weight of the seed was 21.4 g. After the seeds are pelletized, the thousand-grain weight was 70.0 g, the seedling emergence rate of pelletized seeds measured under laboratory conditions was 86.20%. The flying speed was set to 3.6 km/h, the rotation speed of the seed metering wheel was 15 r/min, the working height was 1.5 m, the row spacing was 25 cm, and the friction wheel speed was 8000 r/min. The theoretical seeding quantity can be calculated as 38.56 kg/hm^2. The five-point sampling method was used to count emergence rate. Use a rectangular frame (0.5 m×1 m) to delineate the sampling area, and take two adjacent rows in each sampling area, as shown in Figure 9b. The number of seeds in the sampling area was counted and the number of rice seedlings was recorded from the sixth day after sowing. The seedling emergence rate was calculated according to Equation (3). The damage rate of the pelleted seeds in the sampling area is calculated by Equation (4).

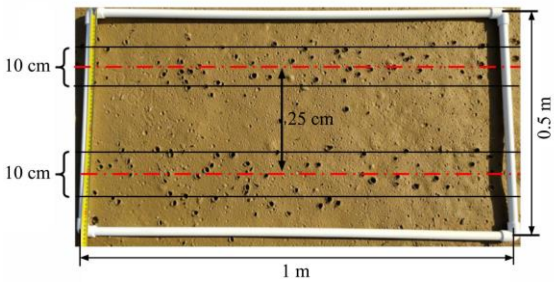
$$A = \frac{N_A}{N} \times 100\% \tag{3}$$

$$D = \frac{N_D}{N} \times 100\% \tag{4}$$

where, A is the seedling emergence rate; D is the damage rate of the pelleted seeds; N_A is the number of seedlings; N_D is the number of damage pelleted seeds; N is the total number of the pelleted seeds.

After sowing, conventional methods were used for field management, and the yield was measured after the rice was mature. When measuring the yield, the rice harvester was used for harvesting, and the fresh grains were weighed. A grain moisture analyzer (Model: LDS-1G, Quzhou Aipu Measuring Instrument Co., Ltd.) was used to measure the moisture content of rice, and converted the measured weight of fresh grain to the weight under the condition of 13.5% moisture content, and then deducted impurities at 1% to obtain the final dry grain quality.

a. Seeding operation in field



b. Seed traces on the ground and sample area

Figure 9 UAV in seeding and seeds on the mud surface

3 Result and discussion

3.1 The performance of seed metering device

3.1.1 Measurement of seed discharge rate

As shown in Figure 10, according to the measurement results, the seed discharge rate under different rotation speed of seed metering wheel levels was calculated. According to the fitting curve, it can be seen that the rotation speed of seed metering wheel and the seed discharge rate had a linear relationship.

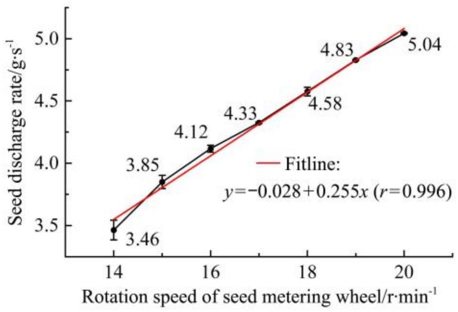


Figure 10 Seed discharge rate under different rotation speeds of seed metering wheel

3.1.2 Stability of seed metering device

The results are shown in Tables 2 and 3. According to the standard NY/T739-2003 (Operation quality of grain drill), the $C.V_1$ should be less than 3.9%, and $C.V_2$ should be less than 1.3%. In this study, $C.V_1$=1.70%, $C.V_2$=1.04%, both meet the requirement.

Table 2 Coefficient of variation of the discharge rate of each row

$\bar{x}_1$	$\bar{x}_2$	$\bar{x}_3$	$\bar{x}_4$	$\bar{x}_5$	$\bar{x}$	S_1	$C.V_1$
111.72	117.16	114.44	114.04	113.92	114.26	1.94	1.70%

Note: $\bar{x}_i$ is the average weight of the five repeated tests in row i, g; $\bar{x}$ is the average value of $\bar{x}_i$, g; S_1 is the standard deviation of the average row weight of each row.

Table 3 Coefficient of variation of total seed discharge rate stability

X_1	X_2	X_3	X_4	X_5	$\bar{X}$	S_2	$C.V_2$
575.9	568.8	561.9	575.1	574.7	571.28	5.95	1.04%

Note: X_i is the total weight of seeds discharged from 5 rows in test i, g; $\bar{X}$ is the average value of X_i, g; S_2 is the standard deviation of the total weight of seeds discharged in five tests.

3.2 The performance of UAV seeding

3.2.1 Seeds distribution characteristics

After the seed coordinates were obtained through image processing, the recognition accuracy was measured. According to the comparison between the X coordinate of the image recognition seed and the actual measured value, it was concluded that the average relative error of the image recognition distance to the manual measurement was 4.25%, and the seed recognition success rate was 95%-98%. According to the data obtained by image processing, drew a map of seed distribution characteristics, as shown in Figure 11.

In order to observe the seed distribution clearly, superimposed the seed scatter plots of the three trials and drew the frequency histogram of each row of seeds in the X-axis direction, as shown in Figure 11a. It can be seen from scatter plot that the distinction between the seed rows was obvious, and the seed density gradually decreased from the center of the row to the edge. According to the frequency distribution histogram of the seeds, the seeds were concentratedly distributed near the center line of the row, and the number of seed gradually decreased toward the edge. In order to further describe the seed row width, the proportion of the number of seeds in different widths was counted, as shown in Figure 11b. As the width increased, the proportion of the number of seeds in the row gradually increased. At 100 mm width, there were 60%-70% of the seeds distributed in this width range.

There are many reasons for the error of the seed landing position within the same row. The irregular shape of pelleted seeds will lead to different directions of force on the seeds, which will affect the initial movement direction of the seeds. Secondly, the wind field generated by the UAV will affect the movement of the seeds in the air. The jitter of the body when the UAV is flying will also affect the stability of the initial shot direction of the seeds.

3.2.2 Evaluation of field seeding effect

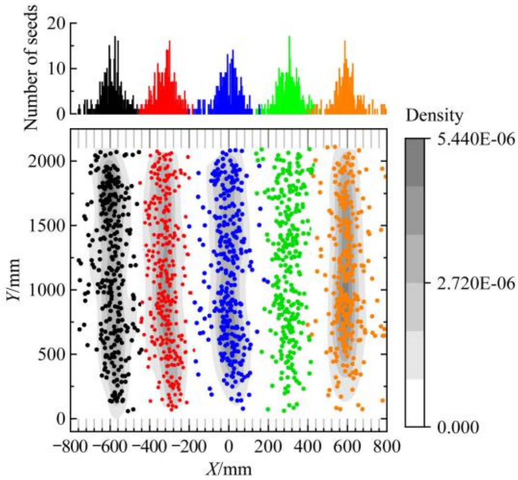
After seeding, the seed discharge weight was 9.9 kg, and the actual seeding quantity was 39.29 kg/hm^2. According to Equation (3), the deviation rate of seeding quantity was 1.89%.

$$P_{zz} = \frac{Q_{zs} - Q_{zy}}{Q_{zy}} \times 100\% \tag{3}$$

where, P_{zz} is the deviation rate of the seeding quantity, %; Q_{zs} is the actual seeding quantity, kg/hm^2; Q_{zy} is the theoretical seeding quantity, kg/hm^2.

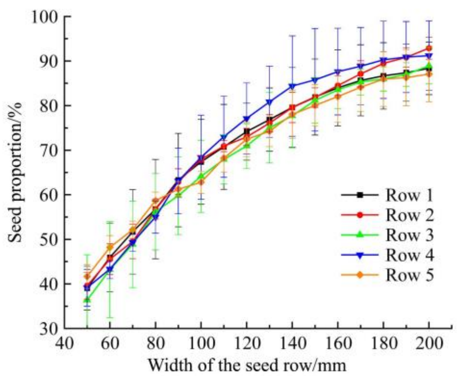
The standard NY/T739-2003 states that the deviation rate should be within ±2%, In this test, the deviation of the seeding quantity was acceptable.

According to statistics, the total number of pelleted seeds in the five sampling areas was 553, of which the number of damaged pelleted seeds was 4, the damage rate of pelleted seeds was 0.72%. It should be noted that the damage only represents the damage of the pelletized material, and no broken seeds were found. The seedling emergence rate statistics were started on the 6th day after seeding. The emergence rate increased rapidly from 62.16% to 79.82% within 6 days, and slowly after the 12th day. After the 14th day, the seedling emergence rate stabilized, and eventually reaching 82.63% which was close to the laboratory result of 86.20%. The seedling emergence rate changed with time are shown in Figure 12a.



Note: Figure 11a is the result of superimposing the scatter plots obtained from three experiments. Different color points are used to distinguish different rows. The background of the scatter plot is the seed distribution density cloud image obtained by the two-dimensional kernel density estimation method. The top of the figure is a histogram of the frequency distribution of seeds in the width direction. Its horizontal axis is the same as the scatter plot, and the vertical axis is the number of seeds.

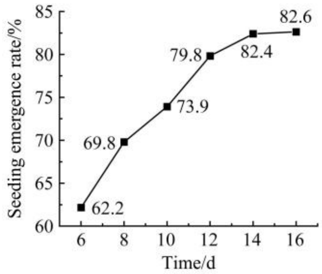
a. Seed distribution scatter plot with density and histogram of seed frequency distribution in each row



Note: In Figure 11b, the horizontal axis is the width of the seed row, and the vertical axis is the proportion of the seed within the width range, and different colors are used to distinguish different seed rows. For example, 100 mm on the horizontal axis represents the range (μ-50, μ+50), where μ is the average value of the X-axis values of the row of seeds in the scatter chart. The number of seeds in the range (μ-50, μ+50) divided by the total number of seeds in the row is the ordinate value, and it is expressed as a percentage.

b. Proportion of each row of seeds under different seed row widths

Figure 11 Seed distribution characteristics of UAV seeding



a. Emergence rate with time

b. Rice seedlings on 14 d

Figure 12 The seedling emergence rate

Figure 12b was the field conditions on the 14th day after seeding, and the rows were obvious. The straightness of the row was greatly affected by the flight stability of the UAV, and it was affected by the lateral wind during the operation, which will reduce the straightness of the rows.

The rice was harvested on September 6, 2021, and the yield was measured. The actual harvested area was 0.023 hm^2, the fresh weight of grain was 177.22 kg, and the measured moisture content was 22.01%. The actual yield can be calculated to be 6775.50 kg/hm^2.

4 Conclusions

A novel UAV-based shot seeding device with the advantage of the compact structure of the whole machine, the five rows seeding operation simultaneously, adjustable seed discharging rate, and stably seeding was designed. The following conclusions were obtained through the experiments in laboratory and in field:

(1) Stability of the seed metering device

On the basis of determining the relationship between the rotation speed of the seed metering wheel and the seed discharging rate, the stability of the seed metering device in the total displacement and the displacement of each row was studied. The results of discharge rate showed that when the rotation speed of seed metering wheel was 15 r/min, the coefficient of variation for the consistency of each row's displacement and the coefficient of variation of the total displacement were 1.70% and 1.04%, respectively.

(2) Distribution characteristics of pelleted rice seed sowed by the shot seeding UAV

In the mud trough experiment, the method of image recognition and processing was used to measure the position coordinates of the pelleted rice seeds. A scatter plot of the distribution of seeds on the ground was established, and the rowing effect of seeds was significant. The number of seeds presented a distribution characteristic of increasing gradually from both sides to the center in the width direction of the seed row, and the number of seeds within the width of 100 mm accounted for 60%-70% of the total number of seeds in the row.

(3) Field UAV seeding and the yield

The feasibility of this seeding method was verified by in-field UAV seeding test. By counting the number of pelleted seeds in the sampling area, it was found that the damage rate of the pelleted seeds was 0.72%, and no damaged rice seeds were found. According to the theoretical seeding quantity and the actual seeding quantity, the deviation of seeding quantity was 1.89%. The seedling emergence rate was 82.63%, and the yield was 6775.50 kg/hm^2 after 108 days of seeding.

This study was exploratory research in the field of UAV seeding, and there are still many related researches to be carried out, especially the problems of seed row effect, structural parameter optimization and life of wear parts need to be further studied.

Acknowledgements

This research was funded by the Laboratory of Lingnan Modern Agriculture Project (Grant No. NT2021009); the Project of key R & D program of Guangzhou of China (Grant No. 202206010149); in part by the Science and Technology Plan of Jian City of China (Grant No. 20211-055316 and [2020]83), Rural Revitalization Strategy in Guangdong Province (2020KJ261) and Science and Technology Plan of Guangdong Province of China (2021B1212040009). We also thank the anonymous reviewers for their critical comments and suggestions for improving the manuscript.

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