

## Research Article

### Pneumatic Precise Radish Seeder

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**Abstract:** In order to solve the problem that the seeding method of radish is still manually dibble seeding or drilling by simple machinery to realize large-scale cultivation of the radish and reduce its labor input and improve operation efficiency, a precision radish seeder used to large-scale plant radishes was to be developed. It adopts the suction principle to realize precise dibble seeding of radish. It can be done either in ridge, ditching, sowing, covering soil and plastic suppression operation. Field tests have proved that the seeder is stable seeding performance and good sowing uniformity and sowing depth coherence, so it meets the radishes grown agricultural requirements.

**Keywords:** Field experiment, pneumatic, radish, ridging device, shaping press roller

#### INTRODUCTION

The radish is a kind of widely cultivated crop in China. It needs to sow its seeds within a short farming season according to relevant agricultural requirements for better growing conditions of crops. Instead of mechanization, radish seeding still takes manual spot seeding or simple mechanical drilling. High labor intensity and low operation efficiency make it hard to realize large area planting, resulting in small production capacity and low productivity effect (Zhang *et al.*, 2012; Zhao *et al.*, 2005). Unavoidably, it wastes labor, time and money, all of which hinder the progress of the radish planting. Great losses will be brought in the process of large area seeding of the radish due to the delay of the farming season. Presently, radish seeds on sale are too expensive. Accordingly it must waste seeds as few as possible in the course of seeding operation. Therefore, radish seeding must take precise bunch planting to ensure the most reasonable field distribution of seeds, precise seeding quantity and regular seed spacing. It offers best conditions for seeds growing, saves expensive seeds and reduces thinning in later period. It ensures high and stable yields of the radish. Therefore, it is urgent to design a type of radish precision seeder.

Seed-metering device is the decisive part of the seeding precise of the seeder (Liao *et al.*, 2012; Liu *et al.*, 2008; Zhao *et al.*, 2011). At present generally used seed-metering devices include mechanical ones and pneumatic ones. Pneumatic seed-metering devices include pneumatic, barometric and air-swept ones. The commonly applied pneumatic seed-metering device in China is mainly used in corn seeding. At present, in China, sowing method of radish is mainly dibble

seeding artificially and few of mechanical seeding. Seed-metering devices for radish mechanical seeding are mostly roller types or indented ones, which are uneasy to control seeding amount and easy to clog, also having high seed losses, because of extremely tinny radish seed, light thousand grain weight, expensive price and low seeding amount (Zhang *et al.*, 2012; Zhang, 2005). It is hard to ensure fine and precise seeding of radish due to the adverse effects to seeding uniformity and stability (Yang *et al.*, 2011; Liu *et al.*, 2009). Tests have proved that seed metering performance of pneumatic seed-metering device is far superior to that of mechanical seed-metering device, which saves seeds, injuring no seed. It is universal to seeds of different dimensions, having high seeding uniformity and being easy to achieve precise seeding (Huali *et al.*, 2015; Zhao *et al.*, 2013).

In this study it designs a pneumatic radish precision seeder, which may by one time complete all operations such as ridging, leveling, seeding, earthing, rolling and shaping.

#### METHODOLOGY

**Constitution and operation principle of the radish pneumatic precision seeder:** The radish pneumatic precision seeder is linked with the tractor by three-point suspension of better motility. It is composed of ridging device, framework, ridge strike-off board, seeding opener, ground wheel, pneumatic seed-metering device and shaping roller, shown in Fig. 1.

The ridging device is installed on the framework front beam. The seeding openers and ground wheels are installed on the framework middle beam. Ground

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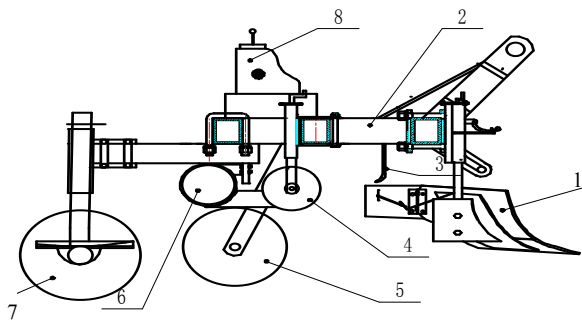


Fig. 1: Structure diagram of radish seeder

- 1: Ridging device; 2: Framework; 3: Ridge strike-off board; 4: Seeding opener; 5: Ground wheel; 6: Pneumatic seed-metering device; 7: Shaping roller; 8: Gear box

wheels are distributed in both sides, ranging in the well-ridged furrow in parallel. The seeding openers for ditching are separately installed in the right above of two ridges. The seed-metering device is installed on the framework back beam, connecting the seed dropping opening with the protecting seeds device that installed on the seeding opener, accurately sowing radish seeds. Installed at the back of the framework, as two symmetrical cone frustums, the shaping rollers completely shape and roll the ridge, sides of the ridge and the furrow bottom to accomplish the seeding.

### Key parts design:

#### The ridging device:

**Structure and principle of ridging devices in both ends:** The radish is ridge cultivation and the ridging quality is one of the key factors for its high quality and quantity. In different regions there are various arable land soil, structure, litter quantity and site preparation quality. The operating environment of the seeder is complicated and rough. The abovementioned conditions make it difficult to design the ridging device. Considering that the reasonable structure design and layout of the ridging surface have direct effect to the ridging, it requires high performance of the ridging device.

The agricultural requirement for row spacing is 500 mm, ridge height 180-200 mm, ridge width 120-160 mm. In different regions radish cultivation requirements are not the same. Hence the designed seeder has adjustable row spacing, ridge height and ridge width.

The designed ridging device uses two types of ploughshares cooperatively. One is composed of ploughshare longitudinal beam of adjustable depth and the plough that is composed of the body and the adjustable cleaner bar. They are installed in both sides of the framework, left and right, shown in Fig. 2.

The plough body is welded by the ploughshare, the plow arm and the reinforcing board. The end of the plow arm is connected with the ridge adjustment plate

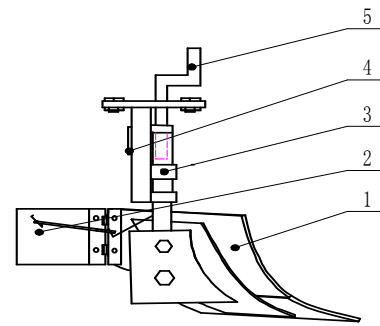


Fig. 2: Structure diagram of both sides ridging plough

- 1: Plough body; 2: Adjustable cleaner bar; 3: Ridging plough longitudinal beam; 4: Installation plate; 5: Adjustable crank

by the hinge. On the ridge adjustment plate there installs the adjustable plate with several holes. Through coordinating different holes with the fixed pin on the upright, it changes the angle between the ridge adjustment plate and the plough body to finally adjust the ridge width. The ridging plough longitudinal beam is composed of the fixed tube and the correctional tube. The fixed tube applies the 40 mm<sup>2</sup> tube. The correctional applies the circular tube of 34 mm the diameter and 6 mm the depth. The adjustment tube, passing the guide tube welded on the fixed tube, maintains the correctional tube and the adjustable crank seat in the centerline. On the top of the correctional tube it welds screw nuts, cooperating with the screw thread at the bottom of the adjustable crank to adjust the ridging plough. It is fixed to the framework front beam by U bolt.

**Structure design of the middle ridging device:** The middle ridging device is welded by two surface plough structures. The longitudinal beam is composed of the guide tube and the down correctional tube. The guide tube applies 50 mm<sup>2</sup> tube and down correctional tube applies 44 mm<sup>2</sup> tube. On the top of down correctional tube it welds the screw nut, coordinating with the stretching screw installed on the top of the guide tube to adjust the depth of the middle ridging device. It is fixed to the framework front beam by U bolts. Figure 3 shows its structure.

#### Pneumatic seed-metering device:

**Structure and operation principle:** The vertical plate pneumatic seed-metering device is composed of the cylinder assembly, the seed chamber, the seed plate and the seeds cleaning device. Figure 4 shows its structure sketch. The cylinder is fixed with the seed chamber by bolts and the seed plate cooperates with axles through the shaped hole.

When the seeder is in operation, seeds are in the tank of the seed-metering device. The seed plate

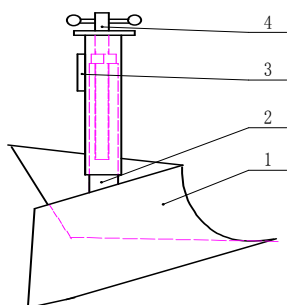


Fig. 3: Structure diagram of middle ridger  
1: Plough body; 2: Ridging device column; 3: Installation plate; 4: Stretching screw

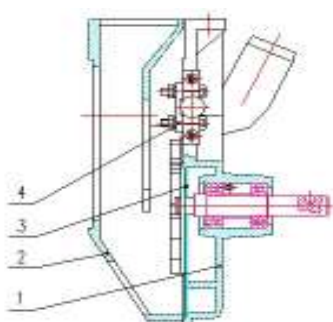


Fig. 4: Structure diagram of radish seed-metering device  
1: Cylinder assembly; 2: Seeds chamber; 3: Seeding plate; 4: Seeds cleaning device

separates the cylinder with the seed chamber. The cylinder connects the fan through the flexible pipe. When the fan operates, in the cylinder there has the vacuum degree. Due to differential pressure, pneumatic holes on the seed plate become the gas passage and create the suction. Consequently seeds in the chamber are sucked and rotate with the seed plate. When they are moved to the scraping device, extra seeds are scraped and only one seed rotates to the sowing part. After the negative pressure disappeared, the seed is fallen into the ditch under self-weight.

**Seeding plate:** Radish seeds have irregular shapes and different sizes. If the seed suction hole diameter is oversize, it is likely that one hole will suck several seeds and it has to reseed. If the diameter is undersize, it is likely that the suction is not enough to suck seeds on the hole and will lead to omitted sowing. Therefore, it is important to design a proper diameter of the seed suction hole, also a key to ensure single precision sowing.

The hole diameter shall be determined by the minimum diameter of radish seeds, which is 1.66 mm after the sampling measurement. Accordingly it selects the hole diameter 0.8, 1.0, 1.2 and 1.5 mm, respectively as the factor level. Seed suction holes are uniformly distributed on the seed plate. Considering actual operating speed and seeding uniformity of the seeder, it takes 28 holes as factor level. Table 1 shows the experimental data in the lab, taking 28 holes as the norm and contrasting the seed plate of diameter 0.8, 1.0, 1.2 and 1.5 mm, respectively.

Considering experimental factors, it determines that the seed plate diameter is 1.0 mm.

**The seeds cleaning device:** In the course of the seed suction, due to the size of diameter and the negative pressure, several seeds will be sucked on the same seed suction hole and rotated with the suction plate. Single precision seeding requires that when seeds rotate to a certain angle, extra seeds remained in the pneumatic hole are to be cleared and fallen into the seed filling part by gravity. Finally only one seed is stably in the seed suction hole. To clear extra seeds, the seeds cleaning part in the seed-metering device is also important, which is coordinated with the seeds separator. The seeds cleaning device is helpful to upgrade the separation precision but possible to break seeds. Consequently it is crucial to research the seeds cleaning device. If it has excellent performance, extra seeds are to be cleared in the seeds cleaning part without any hurt to seeds, having low re-seeding rate. On the contrary, it has high re-seeding rate due to the poor function of the seeds cleaning.

The pneumatic seeder takes various seeds cleaning devices, such as vibrating type, air-sweeping type, brush type, scraper or lever type. This seed-metering device cooperatively uses two seeds cleaning plates. One takes the circular arc upper cleaning piece that is tangent to the seed suction hole, in order to scrape extra seeds in the upper part of the hole. The other takes the eccentric circle made of plastic sheets, being locked and installed to the window of the seed-metering device by bolts, in order to scrape extra seeds in the lower part of the hole. So that only one seed is accessible to reach to the seed opening.

**The shaping press roller:** Basically the radish is under planting pattern of ridge. Seedbed is irregular due to the loose ridge soil. When seeds are fallen to the seedbed, the germination percentage is influenced by the loose touch to the soil. In the later period of the seeding, after the irrigation, the ridge will be sunk and

Table 1: Date statistics of different hole diameter seeding plate test experiment

Hole diameter (mm)	Repeat-sucking rate (%)	Leak-sucking rate (%)	Single seed rate (%)
0.8	1.08	12.34	86.58
1.0	2.13	4.35	93.52
1.2	8.73	2.21	89.06
1.5	22.42	0.00	77.58

Table 2: Data statistics of radish seeder uniformity

Field number	Setting space between the plants (cm)	Avg. space between the plants (cm)	Leak-sowing rate (%)	Repeat-sowing rate (%)
1	13	14	4.22	0
2	10	9.5	2.04	0
3	17	16.2	5.68	0

Avg.: Average

Table 3: Performance test data statistics of radish seeder

Field number	Rate of damaged seeds (%)	Theoretical space between plants (cm)	Avg. space between plants (cm)	Repeat-sowing rate (%)
1	0	10	9.5	0
2	0	13	14.0	0
3	0	17	16.2	0

Field number	Leak-sowing rate (%)	S.D. of space between plants	Variation coefficients of space between plants (%)
1	2.04	2.93	30.88
2	4.22	3.47	24.79
3	5.68	4.48	27.65

Avg.: Average; S.D.: Standard deviation



Fig. 5: Shaping press roller



Fig. 6: Seedling emergence and growth situation

cracked. As a result, seeds are to be deviated from the seedbed or exposed, which greatly cut the emergence rate. Without pressing, the soften ridge soil will lose moisture. After the emergence, seedlings cannot survival due to drought. It considers radish cultivation and analyzes structures of various press rollers. As a new type of shaping wheel, the pressing device shapes and slightly rolls the ridge and its sides, also being able to perform all-round shaping and pressing to the ditch. So that it is possible to solid the ridge soil, to tightly and completely touch with seeds and to make the ridge have fine appearance. It has high performance in maintaining the moisture and is advantageous in emergence. It shows in Fig. 5.

When the shaping press roller is in operation, three huge wheels are running in the middle of the trench and two small ones in the ridge. Huge ones and small ones are separated respectively to avoid that vast wet soil are adhered to the wheels.

**Field test:** To test the seeding uniformity of the seeder, it performed the field test of the prototype at the test field of Xiao’ertai test station in Zhangjiakou City. It measured and recorded the seed metering within

continuous 20 m/ridge by 3 different row spacing of 9, 13 and 17 cm, respectively. The data is shown in Table 2.

After the seeding, it inspected seedlings and recorded data. Figure 6 is the emergence after the trial and growth in later periods.

Comprehensively analyzed the inspection after the emergence of three different trial plots, according to related test requirements of GB/T6973-2005 Single (Precise) Seeder Test Method, the related performance test result of the seeding is as follows Table 3.

After the analysis of test data, it concludes that the seeder has steady performance, uniform seeding and even sowing depth. It satisfies agricultural requirements of radish cultivation.

## CONCLUSION

- It designs a new type of the seeds re-cleaning device, cooperating with the original precise seed-metering device to cut re-seeding rate of the seed-metering device and to satisfy precise seeding requirements.
- Under the same condition of rotating speed and vacuum degree, when the diameter is 1.0 mm, it may have the best seed metering performance.
- The field experiment shows that the radish seeder meets agricultural requirements of radish cultivation.

## ACKNOWLEDGMENT

The authors thank 2015 Science and Engineering Fund Projects of Agricultural University of Hebei “The Pneumatic Millet Precise Seeder” for support.

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