

Design of 2BF-4 Flax Seeder

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Keywords: Rain farming, Flax, Seeder, Device for separate application of fertilizer and seed, Hilly profiling.

Abstract. Aiming at the requirement of planting flax in arid region of middle and east of Gansu Province, a 2BF-4 type flax seeder with 11.03~29.4kw tractor as its power was developed, which used the combination of short wing angle fertilization opener and double disc seeding opener to Device for separate application of fertilizer and seed, double disc seeding opener, monomer profiling, The rear spiral groove wheel seed-metering device and the independent suppression wheel monomer profile. The seeder has the average spacing 300mm, the fertilization depth 80~100mm, the sowing depth 20~50mm, the whole machine wide 1249mm, the high 1170mm, the length 1020mm, each row sowing system independent work, does not affect mutually, satisfies the Gansu Middle East loess Plateau rain farming agricultural area gentle slope (<15°) and horizontal terrace for flax seed technology requirements.

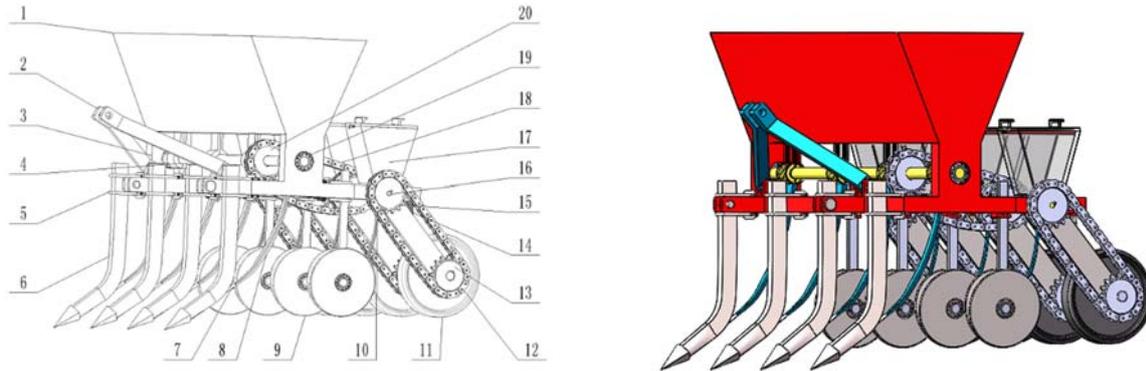
1. Introduction

Flax, that is, oil with flax, its seeds can be extracted oil, is a kind of edible oil-oriented oil-bearing crops. China's flax mainly planted in north China, northwest high altitude, cool climate or drought, poor soil fertility areas [1]. At present, the available flax Seeder can't adapt to the development of modern agriculture, while others are not reported [2]. In the eastern part of Gansu Province, Loess is especially developed, suitable for planting flax[3], the study shows that climate change has a significant impact on the agricultural production in the Loess plateau, affected by this effect, the whole growth period of flax is extended trend [4,5], so it is urgent to develop mechanization of flax cultivation In the Loess plateau rain-raised agricultural area gentle slope (<15°) and horizontal terrace of the soil loose [6], measured, 0~20cm soil stability is only 350~500kpa[7], mainly rain-raising, little precipitation, low grain production. Therefore, the flax seeder not only satisfies the agronomic requirement of flax sowing, but also realizes the sowing requirement of satisfying the environment of rain-raised agricultural area. According to the characteristics of soil, climate and topography in the rain-raised agricultural area of central and eastern Gansu Province, the 2BF-4 type flax Seeder was designed.

2. Overall Structure and Working Principle

2.1 Machine Structure and Technical Parameters.

The Loess Plateau in the Middle East of Gansu province has loose soil and is affected by sowing season, fertilization opener ahead of the operation will appear in front of the mound, in order to improve the pass, the opener and the rack through the U-bolt fixed connection, so that the overall profile, adjustable spacing, in the top of the fertilization ditch by the double disc opener out of the ditch, monomer profiling, To improve the pass rate and the success rate of seeding, the structure of 2BF-4 type Flax Seeder is designed as shown in Figure 1, mainly by the fat box, suspension mechanism, rack, fertilizer, short wing angle opener, guide fertilizer tube, double disc opener, guide Seed tube, suppression wheel, seed-metering device, such as the composition of the box. The main technical parameters are shown in table 1.



(a) Structure Chart

(b) Three-dimensional entity diagram

1. Fat box; 2. Suspension mechanism; 3. Rack; 4. Fat-discharging device; 5. U-type bolts; 6. Short wing angle opener; 7. Pass the fertilizer channel; 8. Guide fertilizer tube; 9. Double disc opener; 10. Guide seed tube; 11. Suppression wheel; 12. Chain I; 13. Sprocket I; 14. Spring; 15. Sprocket II; 16. Metering device; 17. Kinds of box; 18. Chain II; 19. Bearing; 20. Sprocket III.

Fig 1. Structure sketch of 2BF-4 flax Seeder

Table 1. Technology parameters of 2BF-4 flax Seeder

Traction Power	11.025-29.4kw
Working width	1249mm
Seeding Spacing	300-330mm
Number of seeding lines	4row
Fertilizer opener Depth	80-100mm
Depth of seeding opener	30-50mm
Thickness of soil cover	30-50mm
Efficiency	0.1-0.3hm ² /h

2.2 Working Principle.

As shown in Fig. 1, the flax Seeder is pulled by a tractor with a power of 11.025~29.4kw, and the three-point suspension method is attached to its tail. Before the seeder work, must carry on the detection adjustment, according to the plot size, adds the fertilizer and the seed. The seeding system of the flax Seeder is four independent systems, each of which has a double disc opener, a guide seed tube, a seed-metering device and a kind of container, which do not affect each other during work. As the tractor begins to advance, the planter is towed by the tractor, and the planter is lowered by the suspension device and the sowing depth is adjusted. Seeder into the ground began to work, first from the short wing angle opener open fertilization ditch, depth of 80~10mm, while applying seed fertilizer in the ditch, in the soil cover. Then by the double disc opener in the fertilizer ditch second times out of the 30~50mm ditch, the seed feeder evenly out of the seeds, through the guide seed pipe into the ditch. Finally, it was improved by the suppression wheel and the soil moisture germination.

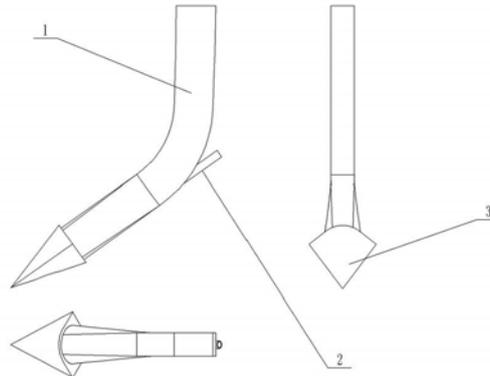
3. Design of Key Parts of Flax Seeder

3.1 Fertilizer Opener

3.1.1 Structure Design and Working Principle of Fertilization Opener

Referring to the two kinds of commonly used device for separate application of fertilizer and seed of No-tillage seeder in China: lateral application and vertical stratified fertilization [8], the mechanism of short wing angle opener and double disc combined species device for separate application of fertilizer and seed was selected. To further improve the short wing angle opener, the retention channel is directly opened to the front end of the ditching device, let it in the ditch at the same time will be the seed fertilizer into the trench, ditching fertilization at the same time, and with the rack through the U-bolt fixed connection, to achieve the overall profile, improve the machine through the sex,

height and spacing can be adjusted, simple and practical. The improved structure of the short wing angle opener is shown in Fig. 2, which consists of a handle column, a row of fertilizer pipe and a hoe.

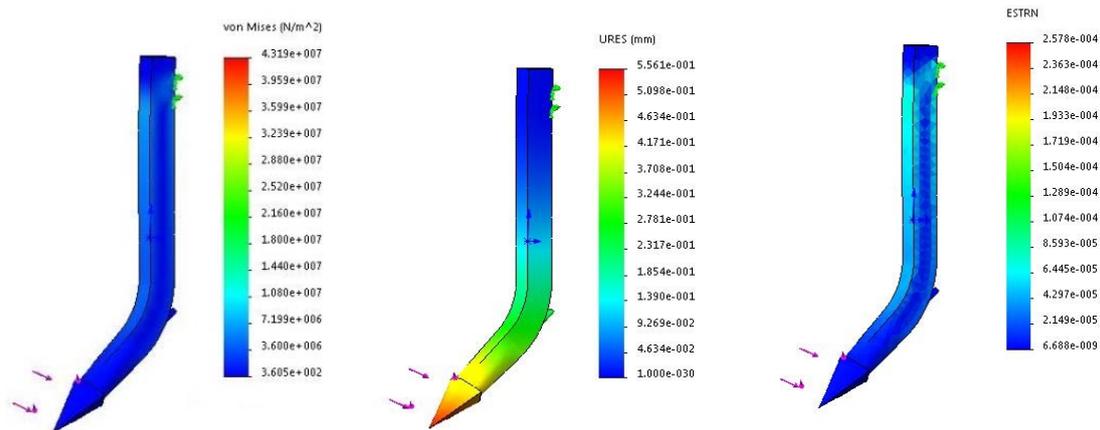


1. Handle column; 2. Fertilizer pipe; 3. Hoe.

Fig 2. Short wing angle opener structure diagram

3.1.2 Stress Analysis of Fertilization Opener

The improved short wing angle opener also needs to be validated by the strength [9,10], the three-dimensional model of the short wing angle opener is drawn in the SolidWorks, and the static stress analysis is carried out. The ditching material is 65Mn steel [11], the contact surface of the frame is fixed surface, and the force of 200N is loaded according to the soil firmness [7] in the shovel tip normal direction, simulating the ditching resistance. The simulation results are shown in Figure 3.



(a) Stress Cloud

(b) Strain Cloud

(c) Displacement Cloud

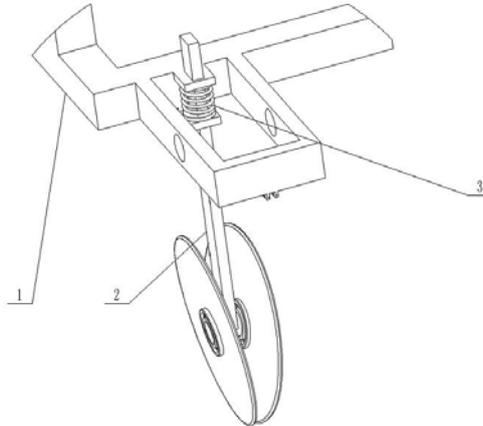
Fig 3. Stress analysis of ditching device

(a) The stress cloud picture of the ditching device shows that the maximum stress is $4.319 \times 10^7 \text{ N/M}^2$, located at the fixed end of the ditching device, but far less than the yield force of the $7.002 \times 10^8 \text{ N/M}^2$, the stress at the top to bottom of the ditching device decreases gradually, and the stress at the tip is minimal, for $3.605 \times 10^2 \text{ N/M}^2$. (b) The graph shows the strain picture of the short wing angle opener, which can be find the maximum strain on the fixed surface of the ditching device 2.578×10^{-4} , along the wall of the ditching device and reaching a minimum 6.688×10^{-7} at the shovel tip. (c) The figure is the displacement cloud of the ditching, the maximum displacement point at the tip of the shovel, reached $5.561 \times 10^{-1} \text{ mm}$, along the ditching wall facing, the change in the displacement is gradually reduced, and finally on the fixed surface to reach the minimum value, for $1 \times 10^{-30} \text{ mm}$. The maximum displacement has little influence on the ditching depth or stability, doesn't affect the working effect of the ditching device.

By the above stress, strain and displacement cloud picture, there can be seen that the ditching device satisfies the design requirements of the flax seeder, satisfies the mechanical characteristics of the material, satisfies the soil condition of the rain-farming agricultural area in the Middle East of Gansu province, and can ditch the fertilization.

3.2 Selection and Calculation of Seeding Ditching Device

The soil is loose when the flax is sown. Therefore, the seeding opener uses double disc opener. Double disc opener in the fertilizer ditch second times, vertical seeding, to enhance the two-disc opener cut off soil and the residual root capacity, the two-disc center in the horizontal direction before and after the difference 26mm [12]. An imitation spring is installed on the double disc opener to improve its passing and ditching success rate, and to reduce the positive pressure during ditching. Double disc opener structure as shown in Figure 4.



Rack; 2. Double disc opener; 3. Profile spring
Fig 4. Schematic diagram of two-disc opener

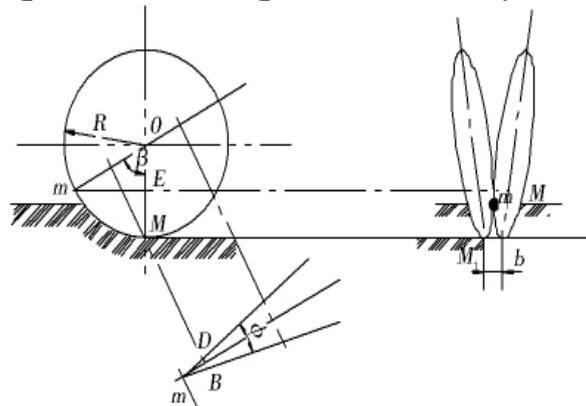


Fig 5. Two-disc gathering point position

The diameter of the disk is generally 300~380mm, the commonly used φ angle is $9^{\circ}\sim 16^{\circ}$; the position of the node is indicated by β angle, the height of M point is equal to the maximum ditching depth, the general β angle is $55^{\circ}\sim 75^{\circ}$, the ditching width depends on the size of the β angle and the height of the M point.

The position of the M point is shown in Figure 5. the double disc opener follows the position of the M point in general to the ground slightly above, its ditching width B is the distance between BD two points, according to the design criterion of the double disc opener, take the β angle about 75° , φ angle is 14° .

Like the following calculation formula:

$$b = BD = 2mB \sin \frac{\varphi}{2}$$

$$mB = \frac{D}{2} (1 - \cos \beta)$$

$$b = D(1 - \cos \beta) \sin \frac{\varphi}{2}$$

Can be concluded that:

$$D = \frac{b}{(1 - \cos \beta) (\sin \frac{\varphi}{2})}$$

According to the results of the study, the width of the short wing type angle opener is 38.6mm [13], while the double disc opener will ditch two times in the fertilizer groove, to reduce the positive

pressure of the double disc opener, the ditching width of the double disc should be less than or equal to 38.6mm.

So:

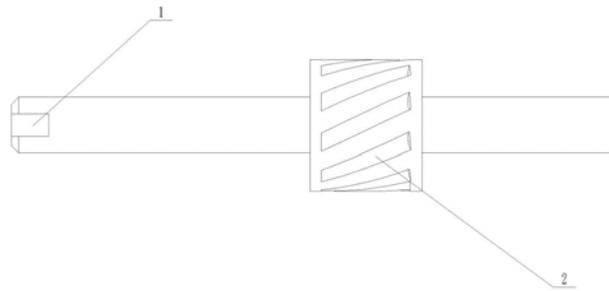
$$D \leq \frac{38.6}{(1 - \cos \beta) \left(\sin \frac{\phi}{2} \right)}$$

Can be concluded that: $D \leq 427\text{mm}$

According to the actual situation of the flax sowing, the disc diameter of the double disc is 350mm, and the width of the ditching is $b=31.61\text{mm}$, the disc material is 65Mn [14], and the modulation treatment meets the requirement of flax sowing.

3.3 Design of Seed Metering Device

The precise seeding of the drilling process is generally to form a clear equal time, uniform and continuous seed flow of the whole case, but it does not meet the ideal requirement [14]. For this reason, as shown in Fig. 6, the seed-metering device of the flax seeder will process the positive groove into spiral groove, use the combination of spiral groove and clear tongue (brush installed above the tongue) to improve the uniformity of seed and the stability of sowing quantity. Flax grains are oblate shape, the diameter of the 3~8mm around, so the diameter of the slot wheel for the $d=35\text{mm}$, the speed of the Groove wheel general in the $n=9\sim 60\text{r/min}$, the length of the Groove Wheel $L=30\text{mm}$, Groove section of the shape of a circular arc, groove width of 10mm, depth $h=5\text{mm}$, number of slots $z=10$, Each groove can be filled with 3~5 seeds.



1.Keyway; 2. Helical grooves

Fig 6. Sketch of the seed-metering device

Then there is a row of seed for each turn of the row:

$$q_1 = \pi d L \gamma \left(\frac{a_0 f_q}{t} + \lambda \right) (g/r)$$

The agronomic requirements for flax seed are:

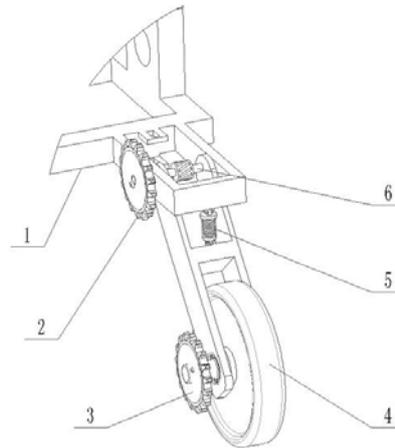
$$q_2 = \left(\frac{\pi D b Q (1 + \delta)}{10 + i} \right) (g/r)$$

The q_1 and q_2 should be equal, ensure that the quantity of the Groove wheel can meet the requirements of agricultural technology.

$$\pi d L \gamma \left(\frac{a_0 f_q}{t} + \lambda \right) = \left(\frac{\pi D b Q (1 + \delta)}{10 + i} \right)$$

3.4 Suppression Devices

The suppression device is composed of a suppression wheel and an imitation spring, which is used to tighten the soil, make the seed contact with the soil closely, and make the seed get more water and nourishment, rooting and germination. The hollow rubber wheel is used in the flax seeder and the pressure is zero pressure. Rubber ring compression deformation by its own resilience, its advantages are constant pressure, simple structure, work stability, rubber ring deformation after compression and recovery, coupled with the role of imitation spring, the suppression device can be competent for mountain repression and power transmission task [14]. The suppression wheel structure is shown in Figure 7.

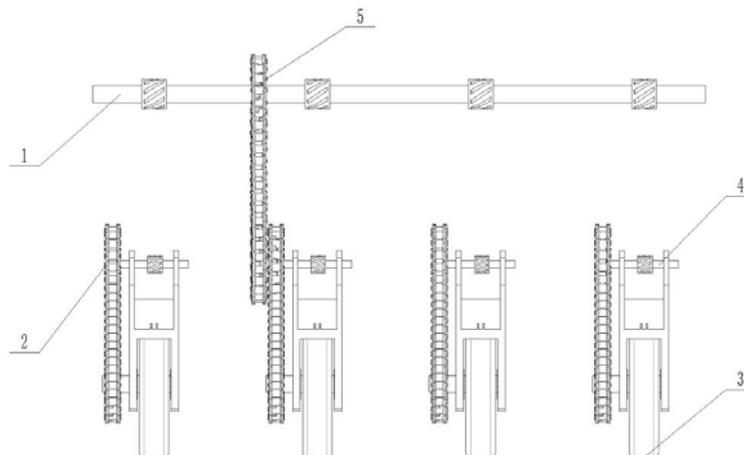


1.Rack 2. Driven sprocket; 3. Active sprocket; 4. Suppression wheel; 5. Imitation spring; 6. Seed metering device.

Fig 7. Suppression devices

4. Design of Transmission Device

The transmission system of flax Seeder is mainly chain drive, and the power source of seed metering device and fertilizer collector is the suppression wheel. A sprocket with 25 teeth is installed on the left side of the crushing axle, and a sprocket with a tooth number of 17 teeth is fixed on the seed-metering shaft, and the transmission ratio is 0.68. A sprocket with a tooth number of 25 teeth is fixed on the middle position of the seed-metering device, and a sprocket with a tooth number of 17 teeth is fixed in the corresponding position of the fertilizer plant, and the transmission ratio is 1.47:1. In this way, the suppression wheel, the seed-metering device and the fertilizer plant are connected by a chain, and when the tractor moves forward, the suppression wheel drives the seed-metering device and the fertilizer-discharging unit to begin work. Transmission route as shown in Figure 8.



1.Fat-discharging device 2. Seed-metering chain; 3. Suppression wheel; 4. Seed metering device; 5. Fat-discharging chain

Fig 8. Transmission diagram

According to the traction power required by the seeder is 11.025~29.4kw, the power of the tractor is 21kw, the working speed is 4.5km/h, the speed of the suppression wheel is V_D , the diameter of the suppression wheel is $D=400\text{mm}$, the number of active sprocket teeth $Z_1=25$ and the number of driven sprocket teeth $Z_2=17$, calculate the chain speed $v=0.34\text{m/s}$, consult the mechanical design textbook 9-14[15] Check the lubrication method is a regular artificial lubrication.

In summary, the chain drive related parameters are as follows: The active sprocket tooth number is 25 teeth, the pitch is 25.4mm, the roundness diameter is 202.66mm, the driven sprocket tooth number is 17 teeth, the pitch is 25.4mm, the roundness circle diameter is 138.232mm.

5. Conclusion

The seed-metering device of 2BF-4 type flax Seeder adopts spiral groove, and the combination of spiral groove and clear tongue is used to improve the stability of seeding uniformity and sowing quantity.

The combination of the short wing angle opener and the double disc opener is adopted in the combined type device for separate application of fertilizer and seed. The former ditch the fertilizer, the latter followed by second times in the fertilizer ditch to ditch the sowing, greatly reducing the double disk under the pressure of the soil, reducing the resistance of the machine forward, improve the machine's passing and operating speed, Combined type of device for separate application of fertilizer and seed can not only increase the ability of the hilly profiling, but also improve the adaptability and efficiency of the equipment.

2BF-4 type Flax Seeder meets the agronomic requirements of flax sowing, and meets the requirements of soil, climate and terrain environment in rain-raised agricultural areas in central and eastern Gansu Province.

Acknowledgements

This work was financially supported by China Agriculture Research System (No. CARS-14-1-28).

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