RESEARCH AND DEVELOPMENT OF AN INTEGRATED HEADER FOR SOYBEAN-CORN COMBINED HARVESTERS ADAPTED TO STRIP INTERCROPPING
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大豆玉米复合种植一体化联合收获机割台研究与创制

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ABSTRACT
To address the issue of the lack of suitable integrated harvesters for the soybean-corn intercropping mode in China, this paper designs a 4DYZ-4/2 model soybean-corn integrated harvester header and develops a reliable integrated header with low loss rates during harvesting. This header integrates functions such as snapping soybean stalks, separating soybean and corn, corn snapping and conveying, corn cob cutting, and soybean stem conveying, with innovative structural adjustments to the overall frame, ensuring efficient harvesting of soybeans and corn while reducing the labor intensity of operators. Based on the characteristics and requirements of the soybean-corn intercropping mode, the operational performance parameters and key parts were optimized. The main design parameters include: a header width of 1400 mm, a divider width of 400 mm, a header row spacing of 450 mm, a reel radius of 550 mm, six snapping rollers, a snap roller speed of 4.8 m/s, and a reel rotational speed of 1314 rpm. Field test results show that the header achieves a soybean loss rate of 1.28% and a corn loss rate of 1.42%. The research results confirm the reliability and practicality of this header design, providing technical support for soybean-corn intercropping integrated harvesting.

摘要
针对我国大豆玉米带状复合种植模式下，无成熟适用一体化收获机的问题，本文设计了一种适配于 4DYZ-4/2 型大豆玉米一体化收获机的大豆玉米一体化割台，旨在研究一款能够具有较高收获性能并降低割台损失的一体化割台。该割台集成了两行摘穗板式玉米割台和 4 行大豆专用割台；一体化割台具有玉米拨禾、玉米摘穗和输送、玉米秸秆切割还田、大豆分禾、大豆切割和输送等功能，创新性地采用整体机架结构，确保大豆、玉米同时收获，显著降低机手的劳动强度。基于大豆玉米带状复合种植的特性及农艺要求，通过对相关部件的工作参数分析，设计优化了关键部件：大豆割台拨禾轮半径 550 mm、6 幅拨禾轮、大豆割台宽度 1400mm，玉米割台分禾器宽度400mm、割台行距450mm，拨禾链线速度4.8m/s，拉茎辊转速1314rpm。田间验证结果表明，该割台实际大豆损失率为 1.42%，玉米损失率 1.28%。研究结果验证了该割台设计的可靠性和实用性，为我国大豆玉米带状复合种植一体化收获提供了装配支撑。

INTRODUCTION
Soybeans are one of the four major oilseed crops in China and serve as an important source of protein for food and feed *(Han et al., 2025; Yu et al., 2025)*. They play a crucial role in ensuring national food security. With the improvement of people's living standards and dietary structure, domestic demand for soybeans has steadily increased, remaining stable at approximately 15 million tons annually *(Chatterjee et al., 2025; Baldi et al., 2025)*. Corn is one of the main grain crops, with an annual production of around 600 million tons in China *(Paladines-Parrales, 2025; Boyer et al., 2024)*. Both soybeans and corn are widely grown in China, with notable production in the northeast region. Soybean and corn intercropping, which stabilizes corn yields while increasing soybean yields, has become a significant trend for improving soybean production efficiency *(Wade et al., 2025; Chen et al., 2025)*.

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At present, no mature and effective harvesting equipment exists for the soybean-corn intercropping model. Therefore, designing an integrated harvester capable of simultaneously harvesting soybeans and corn in intercropping systems has become essential.

In recent years, numerous scholars have conducted extensive research on soybean and corn headers to enhance harvesting effectiveness and efficiency, achieving significant progress. For example, *Liu et al. (2023)* developed an advanced header height automatic control system based on a harsh-environment motion controller, effectively addressing challenges in uneven field conditions.

Ni et al. (2022) optimized critical parameters such as the radius of the reel wheel, the reel speed ratio, and the reel wheel's speed to mitigate the tendency of soybean pods to burst during maturity. He also refined the header’s soil removal mechanism to address the issues caused by low pod formation and the ease of soil shoveling during harvesting.

Liu Ji et al. (2025) systematically reviewed and summarized the research status of key components, including soybean headers, transportation systems, threshing mechanisms, and cleaning technologies. Based on these insights, key research areas were identified for the future development of soybean harvesting machinery.

Li et al. (2024) designed a mechanical-hydraulic combined soybean header profiling device, which significantly improved the profiling range through a segmented profiling mechanism.

In the realm of corn harvesting, *Xin et al. (2023)* developed a clamping and conveying device with adaptive adjustment of the clamping and conveying gap based on the thickness of plant stems, using the vertical roller cutter method for ear picking.

Wang et al. (2024) designed a flexible, low-loss corn harvesting cutter, while *Wang et al. (2022)* introduced a high-efficiency, low-loss plate-type corn ear picking device.

Tang et al. (2021) designed an innovative corn ear harvester featuring central stem cutting, flexible ear picking, and rapid seed cleaning capabilities.

Fu et al. (2020) proposed using the rigid-flexible coupling principle to reduce cutter loss and designed a wheeled, rigid-flexible coupling loss-reducing ear picking device.

For areas with different harvesting periods for soybeans and corn, the method of separate harvesting is practical. However, in regions where soybeans and corn are harvested simultaneously, separate harvesting methods present significant challenges. The operation of harvesters for one crop can inadvertently damage the other, resulting in losses. Furthermore, users must invest in separate machines for soybeans and corn, incurring high equipment and labor costs. Separate operations also lower labor efficiency, increase labor intensity, and cause repeated land compaction. These drawbacks highlight the poor adaptability of separate harvesting to soybean-corn strip composite planting systems.

To address these challenges, developing a low-loss, high-efficiency integrated harvester specifically designed for the soybean-corn strip composite planting system is essential. A specialized header for soybean-corn integrated harvesters is a prerequisite for advancing this technology. This innovation is critical for enhancing the mechanization of soybean-corn integrated harvesting, improving labor efficiency, and providing robust equipment support for the mechanized harvesting of soybean-corn strip planting systems.

MATERIALS AND METHODS

Selection of operation modes and overall layout design for the integrated header

Since soybean-corn strip intercropping involves alternating rows of soybeans and corn, this study uses the “4+2” standard planting model (i.e., 4 rows of soybeans + 2 rows of corn) for explanation.

According to the planting model, the integrated harvesting of soybeans and corn offers two operation modes. The first mode, shown in Fig. 1, allows for simultaneous harvesting of 4 rows of soybeans and 2 adjacent rows of corn, with a “loop” operation trajectory. The second mode, shown in Fig. 2, allows for sequential harvesting of 4 rows of soybeans and 1 row of corn on each side.

Both operation modes are feasible; however, the second mode requires the operator to align the header with both sides of the corn rows and adjust the soybean header height simultaneously, demanding a higher level of operational skill and significantly increasing the operator’s labor intensity. In contrast, the first mode requires alignment with only one side of the corn rows while maintaining soybean header height, making it simpler to operate and less labor-intensive.

Therefore, the first operation mode was chosen for this study. Once the operation mode was determined, the layout of the integrated header was finalized.

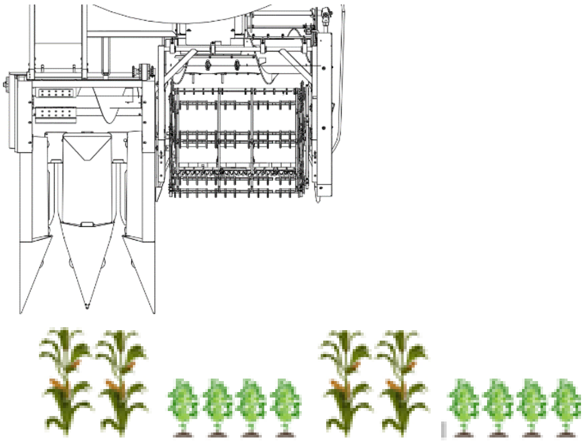

Fig. 1 – Two rows of corn on one side

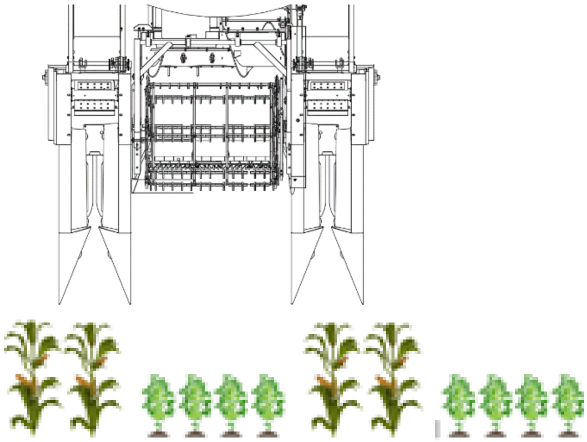

Fig. 2 – One row of corn on each side

To improve the operational quality of soybean-corn integrated harvesting, the integrated header is designed as shown in Fig. 3. The specialized soybean-corn integrated header primarily consists of an integrated header frame, a corn header, a soybean header, and a power transmission system. It is capable of performing a range of tasks in a single operation, including corn stalk separation, soybean stalk separation, soybean guiding, soybean pushing, corn stalk chopping and field return, ear conveying, soybean cutting, and conveying. Compared to separate soybean and corn headers, the integrated header significantly enhances operational efficiency by adopting a simultaneous soybean-corn integrated harvesting approach.

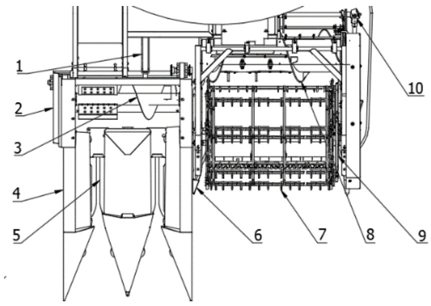

Fig. 3 – Schematic diagram of the soybean-corn integrated header

1. Integrated header frame; 2. Corn header frame; 3. Corn header transverse auger; 4. Corn header divider; 5. Corn header ear-picking roller; 6. Soybean header divider; 7. Soybean header reel; 8. Soybean header transverse auger; 9. Soybean header frame; 10. Power transmission system.

The integrated header is mounted on a single frame, which serves as the base for both the corn and soybean headers. The frame is equipped with hydraulic cylinders at the bottom, enabling the entire header to be raised or lowered. Additionally, the hydraulic cylinders under the corn header allow for adjustments to its operational height.

During the harvesting operation, the header height has little impact on the performance of corn harvesting, while the adjustment range of the soybean header height is relatively small. Based on actual operational observations, the height adjustment range for the soybean header is approximately within 50 mm, which does not significantly affect corn harvesting. Therefore, the appropriate harvesting height for soybeans is used as the reference height for the integrated header. The corn divider and soybean divider separate soybean and corn plants, reducing the mixing of the two crops.

Within the header's cutting width, corn plants and soybean plants are separated and guided into their respective headers. Corn ears are picked by the ear-picking rollers and transported by the transverse auger to the elevator, while corn stalks are chopped and returned to the field by the cutter located at the bottom of the header. Soybean plants are pushed by the reel into the cutting area, where they are cut and transported by the transverse auger to the threshing and cleaning mechanism.

Design of key components and parameters of the integrated header

According to the "Technical code of practice for maize-soybean strip intercropping " issued by the Ministry of Agriculture and Rural Affairs *(Zhong et al., 2024)*, all row spacing for strip intercropping of soybeans and corn must follow these parameters: corn row spacing is 60–70 cm, soybean row spacing is 30 cm, and the distance between soybeans and corn is 70 cm. Based on this planting standard, total width B_{fz} for 4 soybean rows and 2 corn rows:

$$B_{fz} = 300×3+700×2+400=2700 \text{ [mm]} \quad (1)$$

Considering an additional 150 mm clearance on each side of the header to prevent accidental damage to adjacent crops during operation, the total required width for the integrated header B is:

$$B = 2700 -150×2 =2400 \text{ [mm]} \quad (2)$$

According to the above data, the effective harvesting width of the soybean header is 900 mm, 100 mm of surplus width should be reserved on both sides for the working width and 100 mm of transmission mechanism installation space. Thus, the actual width of the soybean header B_{fd} is calculated as:

$$B_{fd} =900 +100×2 +100 =1200 \text{ [mm]} \quad (3)$$

The corn header is measured at 400 mm per row, and the structural width of the machine is 1000 mm. Therefore, the total width of the integrated header B should be:

$$B =1200 +1000=2200 \text{ [mm]} \quad (4)$$

This total width is smaller than the required maximum width of 2400 mm, ensuring that the design meets the overall width and operational requirements for both soybean and corn headers.

RESULTS

Operational parameter calculations for the integrated header

For spring-planted corn, the row spacing is generally 33 ~ 40 cm, In the soybean-corn intercropping mode, the corn planting density is higher, with a row spacing L_f =9 ~ 12 cm. The working speed of the corn harvester is 3 ~ 6 km/h, and the corn in the soybean-corn intercropping mode is densely planted. The number of plants processed per unit time in this mode is about 2 ~ 3 times that of the conventional corn planting mode. To ensure the reliability and safety of the harvester, it is designed based on the highest speed of V_{max} = 6 km/h (1.67 m/s). The pitch of the P38 chain is 38.1 mm. If 8 claws are installed on the chain, the spacing *d* between claws is:

$$d = 38.1 \times\ 8 = 304.8 \text{ [mm]} \quad (5)$$

The claws are evenly distributed on the two chains. For each row of corn, the claw spacing d_1 is:

$$d_1 = \frac{d}{2} = \frac{304.8}{2} = 152.4 \text{ [mm]} \quad (6)$$

This is greater than the 9 ~ 12 cm row spacing in the soybean-corn intercropping mode. Therefore, the claw spacing of the integrated harvester should be reduced. If the number of teeth per chain is reduced, such that every third pitch corresponds to one claw, then the integrated claw spacing d_2 is:

$$d_2 = 38.1 \times 3 = 114.3 \text{ [mm]} \quad (7)$$

Thus, the single-row claw spacing d_3 becomes:

$$d_3 = 38.1 \times 6 = 228.6 \text{ [mm]} \quad (8)$$

In the conventional corn planting mode, the claw chain line speed of the corn harvester is V = 2.3 ~ 2.6 m/s. Based on the maximum line speed V_{max} = 2.6 m/s, the number of claws passing per second n_1 is:

$$n_1 = \frac{V}{d_1} = \frac{2.6}{0.152} = 17.1 \text{ [claws/s]} \quad (9)$$

The corn harvesting capacity Z_y is:

$$Z_{\mathrm{y}} = \frac{V_{\max}}{L} = \frac{1.67}{0.25} = 6.7 \text{ [claws/s]} \tag{10}$$

For the integrated harvester, the number of corn plants harvested per second Z is:

$$Z = \frac{V_{\max}}{L_{\mathrm{f}}} = \frac{1.67}{0.1} = 16.7 \text{ [claws/s]} \tag{11}$$

The number of claws passing per second in the integrated harvester n_2 is:

$$n_2 = \frac{Z}{Z_{\mathrm{y}}} n_1 = \frac{16.7}{6.7} \times 17.1 = 42.6 \text{ [claws/s]} \tag{12}$$

The claw chain line speed of the integrated harvester V_b is:

$$V_{\mathrm{b}} = n_2 d_2 = 42.6 \times 0.1143 = 4.87 \text{ [m/s]} \tag{13}$$

The corn stalk divider can effectively guide corn stalks separately to the entrances of the snapping rollers, bringing them within the snapping claw range for snapping and harvesting. Due to the fragility of corn stalks, they are prone to breaking. If the slope angle of the corn stalk in the divider is too large, the stalks are easily subjected to excessive bending and breakage. In the soybean-corn intercropping mode, the corn row spacing is 400 mm, which is smaller than the conventional planting mode's 550–600 mm. Therefore, the width of the divider must also be adjusted accordingly.

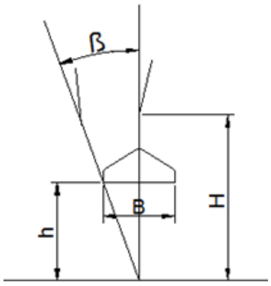

Fig. 4 – Corn divider's width

In the combined harvesting header, to ensure the corn stalks are not subjected to excessive bending and breaking due to the divider, the slope angle β of the corn stalks in the divider must be less than the critical bending angle range of 20 - 30° *(Du et al., 2013)*. As shown in Fig. 4, based on the formula for the slope angle of corn stalks:

$$B_c = 2h \times \mathrm{Tan}\beta \text{ [mm]} \tag{14}$$

Where: B_c is divider width, [mm]; h is the height of the divider's contact point with the ground, [mm]; β is the corn stalk slope angle, [°].

The general height of corn stalks is 600 - 1200 mm, so the minimum divider height $h_{\min}$ = 600 m. Substituting into the formula, assuming the maximum critical bending angle β = 20°, it is obtained:

$$B_c = 2h_{min} \times \mathrm{Tan}\beta = 2 \times 600 \times \mathrm{Tan}20^0 = 436.8 \text{ [mm]} \tag{15}$$

When designing, the parameters are rounded down, so B_c = 400 mm.

During the harvesting process, the corn stalks are pushed forward and inclined by the front end of the divider. If the angle of the divider tip is too large, it will cause excessive friction between the corn stalks and the divider, preventing the corn stalks from sliding along the divider edges. This can lead to the corn stalks being bent or broken. Therefore, the forward pushing force generated by the divider tip must be greater than the frictional force between the corn stalks and the divider.

As shown in Fig. 5.

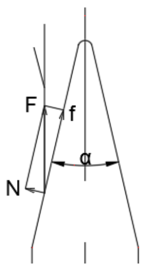

Fig. 5 –The front end of the Corn divider

The relationship is expressed as follows:

$$\begin{cases} F \cdot \cos\frac{\alpha}{2} > f_{\max} \\ f_{\max} = \mu \cdot F \cdot \sin\frac{\alpha}{2} \end{cases} \text{[N]} \tag{16}$$

where: F is the pushing force exerted by the divider on the corn stalks, [N]; f_{max} is the maximum static friction force between the divider and the corn stalks, [N]; μ is the coefficient of friction between the divider and the corn stalks. The coefficient of friction between corn stalks and the divider is *0.2 - 0.6*. Therefore, if *30°* $< \alpha <$ *60°*, the divider angle α should not exceed *30°*, and it is set to *28°*.

The stem pulling roller speed should neither be too high nor too low. If the speed is too high, corn stalks and cobs will experience stronger impact forces, causing the stalks to break and increasing fruit loss and damage. Conversely, if the speed is too low, it cannot match the working speed of the harvester, resulting in incomplete separation of the corn stalks from the stem pulling roller within the operational period. When the corn harvester is operating at 6 km/h, i.e. 1.67 m/s, within the time t when the harvester moves forward by the effective length of the ear-picking roller, the corn stem-pulling roller will pull down the corn stalks completely, complete the ear-picking and pull all the stalks under the stem-pulling roller, and the grass-chopping knife will crush and return them to the field. The height of the corn plant is between 2500 mm and 3000 mm. According to the plant height H=3000 mm, the linear speed of the ear-picking roller V = 3 m/s, the height of the corn ear is 1000 mm, the height of the corn harvesting platform ear-picking point from the ground $h_{\min}$ = 600 mm, the design length of the corn harvesting platform stem-pulling roller L = 0.642 m, and the horizontal inclination angle during operation θ = 25º, then the time t is:

$$t = \frac{L\times\cos\theta}{1.67} = \frac{0.642\times\cos 25^0}{1.67} = 0.35\ \text{[s]} \tag{17}$$

$$V = \frac{3000-600}{1000t} = 6.88\ [\text{m/s}] \tag{18}$$

The stem pulling roller is designed with a diameter 100 mm, so the rotational speed Z should be:

$$Z = \frac{60V}{\pi d_1} = \frac{60\times 6.88}{3.14\times 0.1} = 1314\ [\text{rpm}] \tag{19}$$

In the soybean-corn intercropping mode, the corn planting density is higher, the row spacing is smaller, and the planting density is greater. As a result, the load on the horizontal auger per unit time is greater. The auger's spacing and rotational speed are critical to ensuring smooth and stable transport of corn cobs. If the spacing is too small, the corn cobs may not enter the auger fully, leading to low transportation efficiency. If the spacing is too large, it can cause an excessive increase in the lifting angle of the auger blades, potentially reducing the transportation capacity of the auger. Excessive auger speed can lead to transportation inefficiency, resulting in failure to transport cobs to the conveying mechanism properly. This affects the header's regular operation and increases losses, damages, and energy consumption. Therefore, proper auger spacing and speed are critical for maintaining normal operation as shown in Fig. 6.

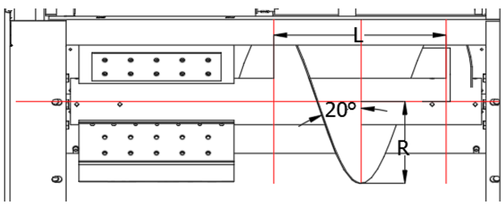

Fig. 6 - Corn Cob Auger

Based on empirical parameters and experimental verification, if the blade lifting angle of the header auger is α = 25°, and the auger diameter D = 380 mm, the auger blade pitch S is calculated as:

$$S = \pi D \times \text{Tan}20^0 = 3.14 \times 380 \times \text{Tan}20^0 = 388.6\ \text{[mm]} \tag{20}$$

Rounding to the nearest practical value, the blade pitch is set to 390 mm. The cob diameter generally ranges from 16~25 cm, with a maximum length of 35 cm. Thus, the auger blade spiral diameter must be greater than 350 mm. Allowing for a 10% safety margin, the spiral diameter is set to 385 mm, and the blade pitch of 390 mm is considered suitable. To ensure stable downward transport and reduced load, the rational spiral diameter, blade pitch, and transport efficiency parameters must be optimized to ensure smooth and reliable auger operation. These parameters also improve the overall stability and efficiency of the soybean-corn header.

Table 1

Main parameters of the header device for corns

Parameter	Value
Dimensions (L×W×H) (mm)	1200 ×1000 × 850
Total weight (kg)	850
Divider width (mm)	1000
Header row spacing (kg/s)	450
Loss rate (%)	≤1.0

In the soybean-corn intercropping mode, the standard row spacing for corn planting is 400 mm. the divider width is set to 400 mm. Considering all factors, the overall divider width is adjusted to 450 mm. Based on operational experience parameters and working requirements, the structure and performance parameters of the corn header were calculated and optimized. The final main parameters of the corn header are shown in Table 1. The header's structure ensures reasonable operational width and stable harvesting performance, suitable for various terrain and working conditions, ensuring operational stability.

Soybean Header Parameter Calculation

When soybeans are harvested, they are prone to breakage under applied forces, resulting in grain loss. The reel is the part of the soybean harvester that directly interacts with the crop, helping to guide the soybean stalks into the header while minimizing breakage. To reduce grain loss caused by impact, a wider reel with a lower rotational speed is adopted, therefore, this design adopts a 6-spoke reel, which has a lower rotational speed than the conventional 5-spoke reel. Compared to standard narrow reels, wider reels exert smaller impacts on crops, resulting in lower breakage and loss rates. Reels made of elastic materials like nylon are more flexible and reduce the impact on the plants.

According to practical experience, the rotational speed of the soybean header reel is typically 25~35 rpm, and the maximum value of the rotational speed of the soybean header reel is selected for calculations. For the integrated harvester's maximum working speed is 1.67 m/s *(Jin et al., 2019)*, the reel speed should match the harvester's operational speed. The relationship between the reel speed and the harvester speed can be analyzed using a coefficient λ, defined as the ratio of the reel linear speed to the harvester operating speed. If $\lambda < 1$, the reel speed is slower than the harvester operating speed. In this case, the reel cannot push the soybean plants forward effectively, leading to increased grain loss and reduced harvesting efficiency. If λ=1, the reel speed matches the harvester operating speed, ensuring optimal cutting efficiency, minimal grain loss, and sufficient force to push the plants to the cutter bar. If $\lambda > 1$, the reel speed exceeds the harvester operating speed, which provides the plants with an appropriate cutting margin. This ensures optimal performance by minimizing losses and maintaining operational stability.

Based on operational tests and experience, the recommended reel speed ratio is 1.2~1.4. In this study, the speed ratio of the reel is 1.2.

Therefore, the maximum reel linear speed V_b is calculated as:

$$V_{\mathrm{b}} = \lambda \times V = 1.2 \times 1.67 = 2.00\ [\mathrm{m/s}] \tag{21}$$

The reel radius R is calculated as follows:

$$R = \frac{60V_{\mathrm{b}}}{2\pi n} = \frac{60\times2.00}{2\times3.14\times35} = 0.546\ [\mathrm{m}] \tag{22}$$

The reel radius is rounded to 550 mm.

The soybean plant's height is relatively low, typically with an attachment height of 10 cm, and in some cases as low as 5 cm. During the integrated harvesting process, the harvester must continuously monitor and adjust the header height to prevent issues such as the header cutting too high, causing unharvested losses, or cutting too low, resulting in soil damage, "mud smearing," reduced harvesting quality, and even reduced lifespan of the equipment. In addition, if adjustments are made manually by operators, it increases labor intensity. Therefore, an automatic height adjustment mechanism for the soybean header is necessary to reduce labor effort, improve operational efficiency, and ensure that the soybeans in two rows are accurately guided into the header.

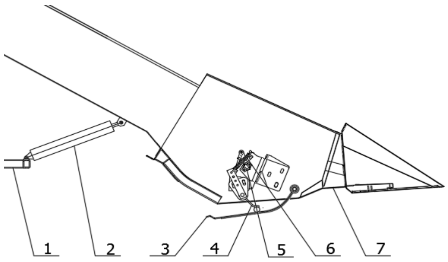

Fig. 7 - Automatic Header Height Control System
1. Frame; 2. Hydraulic cylinder; 3. Simulated profiling plate; 4. Connecting rod; 5. Angle sensor; 6. Tension spring; 7. Header

The automatic height adjustment mechanism for the soybean header primarily consists of a control unit, header, simulated profiling mechanism, and hydraulic lifting cylinder system. During the harvesting process, the simulated profiling mechanism detects the surface height within the working area and automatically adjusts the header height accordingly. The simulated profiling mechanism's connection angle with the working surface is measured in real-time, and its position is adjusted based on surface height fluctuations. The angle sensor detects the change in tilt angle of the profiling mechanism, and the control unit sends signals to the hydraulic lifting cylinder system to adjust the header's height, ensuring proper soybean harvesting height and operational stability. Based on operational experience and requirements, the main parameters of the soybean header were calculated and optimized. The final parameters ensure a reasonable operational width and stable harvesting performance. They are shown in Table 2.

Table 2

Main parameters of the header device for soybeans

Parameter	Value
Dimensions (L×W×H) (mm)	1000 × 1200 × 1150
Total weight (kg)	650
Divider width (mm)	1200
Header row spacing (kg/s)	1.0~2.0
Loss rate (%)	≤1.5
Operating speed (km/h)	4.0~6.0

FIELD TEST

To evaluate the integrated operational performance of the soybean-corn combined harvester adapted for intercropping, a field test was conducted in October 2024 in Zibo, Shandong Province. The test field included soybeans and corn without lodging, with flat terrain. The row spacing was 30 cm for soybeans and 70 cm between soybean and corn rows, while the row spacing for corn was 40 cm. The test field complied with the standard intercropping model for soybean-corn intercropping and met the requirements for the experiment.

Fig. 8 - Field trial

During the test process, the harvester approached the snapping area at a gradual distance of 15~20 m in a deceleration zone and then accelerated through the zone to a working speed of 1.2~1.6 m/s to complete the harvesting operation. The field test results are shown in Tables 3 and 4.

During the experiment, harvesting operations were carried out at a speed of 4.0-6.0 km/s. The average loss rate of corn was 1.28%, the average crushing rate was 0.17%, and the average impurity content was 3.57%. Throughout the three experiments, the maximum loss rate of corn was 1.64%, the maximum crushing rate was 0.4%, and the maximum impurity content was 4.8%. All indicators met industry standards and the corn harvest effect was good.

Table 3

Corn Field Test Result

Test Number	Loss rate /%	Breakage rate /%	Impurity rate /%
1	1.64	0.4	3.4
2	0.85	0.1	4.8
3	1.36	0.02	2.5
Average	1.28	0.17	3.57
Operating speed/(km/h)	4.0~6.0	4.0~6.0	4.0~6.0

During the experiment, the harvesting operation was carried out at a speed of 4.0-6.0 km/s. The average soybean loss rate was 1.56%, the average crushing rate was 0.43%, and the average impurity content was 1.66%. Throughout the three experiments, the maximum loss rate of soybeans was 1.94%, the maximum crushing rate was 0.63%, and the maximum impurity content was 2.13%. All performance indicators complied with industry standards, and the soybean harvesting performance was good.

Table 4

Soybean Field Test Result

Test Number	Loss rate /%	Breakage rate /%	Impurity rate /%
1	1.63	0.63	1.32
2	1.12	0.25	2.13
3	1.94	0.42	1.54
Average	1.56	0.43	1.66
Operating speed/(km/h)	4.0~6.0	4.0~6.0	4.0~6.0

CONCLUSIONS

This article designs a soybean corn integrated harvester suitable for the 4DYZ-4/2 type soybean corn integrated harvester, achieving one-time harvesting of soybean and corn. This harvester integrates two rows of ear picking plate type corn harvesters and four rows of soybean specific harvesters, with functions such as corn plowing, corn ear picking and conveying, corn straw cutting and returning to the field, soybean division, soybean cutting and conveying, etc. Based on the characteristics and agronomic requirements of soybean and corn strip intercropping, the parameter analysis of each component was determined. The radius of the soybean harvester is 550 mm, the width of the soybean harvester is 1400 mm, the width of the corn harvester is 400 mm, the row spacing of the harvester is 450 mm, the line speed of the threshing chain is 4.8 m/s, and the rotation speed of the stem pulling roller is 1314 rpm. Field validation experiments were conducted, and the actual maximum loss rate of soybeans on the harvester was 1.94%, and the maximum loss rate of corn was 1.64%. The indicators met industry standards, and the harvester had good harvesting performance.

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