MECHANIZED DETASSELING TECHNOLOGY FOR CORN SEED PRODUCTION: GLOBAL PROGRESS, KEY CHALLENGES, AND OPTIMIZATION STRATEGIES
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制种玉米机械化去雄技术：全球进展、核心挑战与优化策略

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ABSTRACT
Detasseling the female parent plants is a critical operation in hybrid corn seed production. This article systematically reviews global developments in mechanized detasseling technology for corn seed production. First, it provides an in-depth analysis of two key technologies supporting mechanized detasseling: the biomechanical characteristics of corn tassels and intelligent tassel-detection technologies based on machine vision and photoelectric sensing. Second, the current development of mechanized detasseling equipment is reviewed, and the technical parameters and field performance of representative domestic and international machines are compared in detail. The comparison identifies four major constraints limiting the wider adoption of this technology in China: an insufficient single-pass detasseling rate, poor coordination between machinery and agronomic practices, a high crop-damage rate, and low acceptance among farmers. Finally, three targeted optimization strategies are proposed: developing intelligent and precision detasseling equipment, promoting closer integration of agricultural machinery and agronomy, and strengthening field demonstration and extension activities. This review aims to provide a theoretical basis and practical reference for improving mechanized detasseling processes and supporting the development of more effective detasseling equipment.

摘要
母本去雄是制种玉米的核心生产环节。本文系统综述了全球制种玉米机械化去雄技术的发展动态。首先，深入分析了支撑机械化去雄的两大关键技术：雄穗生物力学特性研究与基于机器视觉、光电传感的智能识别技术。其次，梳理了机械化去雄装备的发展现状，详细对比了国内外主流机型的技术参数与作业性能。通过国内外发展现状比较，明确指出当前制约我国技术推广的四大瓶颈：一次性去净率不足、农机农艺不匹配、作业损伤率高以及农户接受度低。最后，针对性地提出三大优化策略：研发智能精细化装备、促进农机农艺深度融合、加强示范推广。本文旨在为优化机械去雄工艺与装备研发提供理论依据和参考。

INTRODUCTION
Corn can not only be used as a food crop, but also widely applied in various fields such as feed, food processing, medical and health care, light industry, chemical industry, and bioenergy *(Liu et al., 2024; Jahangirlou et al., 2023; Chukwutem et al., 2023)*. According to statistics from the Food and Agriculture Organization of the United Nations (FAO), corn has always been the second largest crop in terms of global cultivation area, second only to wheat. Its total yield and yield per unit area are higher than other major grains such as wheat and rice *(Rosegrant et al., 2009)*. High quality corn seeds are the foundation for ensuring high and stable yield of corn *(Singh et al., 2025)*. China's corn varieties are mainly hybrid varieties, and their hybrid advantage is mainly reflected in the first generation. From the second generation onwards, the advantage gradually decreases, so annual seed production is needed to maintain their potential for increased yield *(Wang et al., 2013; Su et al., 2003)*.

Seed production of corn refers to the process of selecting, breeding, producing, and processing high-quality seeds from superior species of corn through multiple techniques, such as selection, breeding, production, and processing, to be suitable for replanting, expansion, or sowing *(Wych et al., 1988; Liu et al., 2024)*. Compared to regular corn, seed corn has better economic benefits and the planting area has been increasing year by year in recent years *(Shahrokhi et al., 2024; Si et al., 2026)*.

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In China, the planting area of seed corn accounts for about 98% of the total planting area of corn *(Shi et al., 2014)*. Therefore, the sustained high yield and high quality of seed corn are of great significance for food security and economic stability *(Huang et al., 2024)*.

The removal of male parents is the core production process of seed corn. Timely and complete tassel removal effectively prevents self-pollination in seed-production fields, thereby ensuring the genetic purity and quality of the hybrid seed. It may also help reduce the risk of certain field diseases and pests *(Felkl et al., 1988; Darrah et al., 2019)*. Seed purity is a key indicator for evaluating the quality of corn hybrids *(Liu et al., 2024)*, and male removal is the most difficult and difficult key step to accurately control in the hybrid seed production process *(Liu et al., 2014; Tian et al., 2014)*. This article systematically analyzes the current development status of male elimination technology and equipment, identifies the main problems in male elimination operations, and proposes targeted improvement suggestions, in order to provide theoretical basis and reference for optimizing mechanical male elimination processes and equipment research and development.

AGRONOMY OF MALE REMOVAL IN CORN SEED PRODUCTION

To ensure the production of high-quality hybrid seed that meets purity standards, all tassels on the female parent plants must be removed before pollen shedding and preferably before full tassel emergence. The operation should follow the principles of timeliness, completeness, and thoroughness *(Tian et al., 2014; Moreira et al., 2010)*. According to the national standard *(GB/T 17315-2011)*, when the cumulative loose powder plant rate exceeds 1% during the entire male removal process, the seed field is scrapped. At present, there are two main methods for male removal in seed production of corn: manual male removal and mechanical male removal.

Manual detasseling commonly follows the principle of removing the tassels before they fully emerge from the leaf whorl. This operation may involve manually opening or removing the leaves enclosing the tassel, or removing one or two upper leaves before tassel emergence. Care must be taken to ensure that no tassel branches remain and that the plants are not broken or otherwise damaged during the operation *(Han et al., 2011; Czepak et al., 2019)*. Detasseling is preferably carried out in the morning and should be avoided on rainy days. It must be completed before the tassels fully emerge and begin shedding pollen *(Bai et al., 2022)*. The main advantage of manual detasseling is that it can reduce damage to the leaves and plants while allowing the operation to be performed at the most appropriate stage according to the growth condition of each plant *(Lu et al., 2010)*. However, it also has several evident disadvantages, including low working efficiency, high labour intensity, high production costs, unfavorable working conditions, and strong dependence on weather conditions *(Asefa et al., 2026; Han et al., 2011; Cui et al., 2010)*. In addition, manual detasseling generally requires five to seven repeated passes to meet pollination-control requirements. The first three or four passes mainly involve tassel removal, whereas the subsequent passes focus on identifying and removing missed or late-emerging tassels *(Tang et al., 2017; Fan et al., 2021)*.

Mechanical detasseling involves using a dedicated detasseling machine to remove tassels from the female parent plants. This method is particularly suitable for varieties with a relatively high number of upper leaves and a low ear position. The operation is generally initiated when approximately one-third of the tassel has emerged above the uppermost leaf.

During tassel removal, no more than two leaves should preferably be removed, with three leaves regarded as the maximum acceptable number *(Ghețe et al., 2020; Nicoletti et al., 2023)*. After mechanical detasseling, a timely manual follow-up inspection is required to remove missed tassels and any residual tassel branches *(Liu et al., 2010; Wu et al., 2013)*.

However, mechanical detasseling may cause substantial damage to the plants and consequently reduce yield. In addition, detasseling performance remains relatively unstable, with reported removal rates generally ranging from 80% to 90% *(Wilhelm et al., 1995; Wang et al., 2024; Prodanović et al., 2022)*.

Compared with manual detasseling, this method offers several important advantages, including high operational efficiency, less dependence on environmental and human factors, good maneuverability, suitability for large-scale field deployment, and improved working conditions for operators *(Sabljak et al., 2019)*. Therefore, the development and wider adoption of mechanical detasseling remain essential for promoting efficient and large-scale corn seed production *(Zhang et al., 2024; Ghimire et al., 2025)*.

RESEARCH STATUS OF DETASSELING TECHNIQUES FOR SEED PRODUCTION CORN

Mechanical Properties of Tassels

The mechanical properties of corn tassels in seed-production fields are key physical parameters for the design and optimization of detasseling equipment *(Jia et al., 1990)*, and have been studied for many years.

In 1990, American researchers *Jia et al.* pioneered the measurement of the manual pulling force required to remove tassels from different varieties of seed corn. They also analyzed the effects of gripping position, field location, and operating time on the pulling force. The results indicated that the average and maximum manual pulling forces for tassel removal were 58.3 N and 92.5 N, respectively. It was found that the corn variety, gripping position, and field location had a significant impact on the pulling force, whereas the time of day during which the operation was performed showed no significant effect *(Jia et al., 1990)*.

Subsequently, *Zhang et al.* conducted correlation and path analysis on nine stalk traits and the unit volume stalk rupture resistance (UVSRP) using a set of diallel cross combinations. The study found that the length of the tassel main axis showed a highly significant positive correlation with UVSRP, whereas the fresh weight of biomass below the ear, the length of the stalk below the ear, the fresh weight of the stalk, ear height, and the stalk length-to-thickness ratio exhibited highly significant negative correlations with UVSRP. Therefore, an appropriate tassel main axis length can serve as an important reference trait for breeding corn varieties with enhanced stalk lodging resistance *(Zhang et al., 2006)*. Wang conducted experimental and theoretical analyses on the tassel pulling force characteristics, plant elastic modulus, and spatial distribution traits of seed corn plants during the detasseling period. The study obtained the range of pulling forces for two inbred lines, Zheng 58 and PH6WC, at different growth stages, and determined their elastic modulus during detasseling as well as the natural spatial distribution patterns of the plants *(Wang et al., 2016)*. Jin further investigated the pulling force characteristics of tassels during the detasseling period, using Xianyu 335, a corn variety widely cultivated in Northeast China, as the research subject. The results showed that during the stage when the tassel had grown 5-10 cm and before pollen shedding, the maximum pulling force was 56.5 N, and the maximum cross-sectional area was 31.2 mm², with the pulling force being proportional to the cross-sectional area *(Jin et al., 2019)*.

Recently, *Ou et al.* systematically calibrated the physical property parameters of tassels in seed corn. Through mechanical tests, the bending modulus and shear strength were determined to be 46.41 MPa and 0.76 MPa, respectively. Furthermore, simulation tests involving rotary cutting components for tassel removal revealed that vertical feed cutting had the least impact on tassel bending deformation *(Ou et al., 2024)*.

Tassel recognition technology

With the advancement of agricultural modernization and intelligentization, the deep integration of computer technology into agricultural machinery and equipment has become a significant development trend *(Kasal et al., 2025; Rodene et al., 2024)*. Currently, achieving automatic recognition of corn tassels using advanced sensing technologies is a key link in enhancing the precision and intelligence of detasseling operations. Researchers both domestically and internationally have actively explored this direction, primarily focusing on two technical pathways: machine vision recognition and photoelectric sensing *(Shepard et al., 2024; Cao et al., 2025)*.

Machine vision recognition technology

Machine vision technology offers several advantages, including nondestructive operation, high accuracy and efficiency, substantial information-processing capacity, strong real-time performance, and flexibility. It has therefore received considerable attention and has been widely applied in precision *agriculture (Gong et al., 2007)*.

The earliest application of this technology to corn tassel recognition research in China was conducted by Tang Wenbing from China Agricultural University. Tang et al. designed and constructed a corn tassel recognition system based on binocular stereo vision, as shown in Figure 1. The hardware of the system primarily consisted of two CMOS color cameras of the same model, a pan-tilt, lenses, a conversion box, and a laptop computer. The workflow was as follows: first, preprocessing the captured images, using color features as the main basis for tassel extraction; then, obtaining the effective tassel regions through image segmentation techniques, and performing image matching based on the segmentation results using binocular stereo vision technology; finally, calculating depth information to determine the specific three-dimensional spatial position of the tassels *(Tang et al., 2011)*.

a) b)

Fig. 1 - Recognition Effect Diagram (Tang et al., 2011)

a) Original image; b) Segmented image

Kumar et al. proposed a novel method for corn ear detection based on k-means clustering and adaptive threshold segmentation. The study, focusing on the task of corn panicle detection in UAV images, developed a semi-automatic image annotation method to facilitate the rapid construction of labeled datasets for corn crops. A tool developed based on this method can be integrated with machine learning models to provide initial annotation results for given images and supports interactive user modification and refinement *(Kumar et al., 2021).*

Wang et al. compared three object detection models-Faster R-CNN, SSD, and YOLO_X-using UAV imagery and a transfer learning approach. The results showed that transfer learning significantly improved model performance, with YOLO_X performing the best, achieving a recognition precision of 97.16% and a mean average precision (mAP) of 93.60%. The study also found significant differences in detection adaptability across varieties, with Zhengdan 958 showing the best detection results. Moreover, as planting density increased, the mean absolute error of detection rose from 0.19 to 0.75. This research provides a reliable method for high-throughput detection of corn tassels in the field *(Wang et al., 2022)*.

Kurtulmuş et al. developed a corn tassel detection algorithm suitable for outdoor field environments. The algorithm utilizes color information and a Support Vector Machine (SVM) classifier for image binarization based on standard RGB images. It achieves tassel cutting position detection while effectively controlling the false positive rate. On the test set, the correct detection rate of this method reached 81.6% *(Kurtulmuş et al., 2014).*

National standards and seed purchasers impose stringent requirements on the tassel removal rate in seed corn production. Consequently, the identification of missed tassels has become a research hotspot *(Falahat et al., 2023; Ding et al., 2026). Li et al.* proposed a lightweight tassel detection model named MLCE-RTMDet. Based on the RTMDet-tiny architecture, this model employs MobileNetV3 as the backbone feature extraction network to reduce computational load and incorporates the CBAM attention mechanism to enhance multi-scale feature extraction capability for tassels, thereby mitigating the potential performance degradation associated with lightweight networks. Furthermore, the model utilizes EIOU Loss instead of GIOU Loss, further improving the accuracy of tassel detection. This research can provide effective technical support for detecting missed tassels after manual detasseling in corn seed production fields *(Li et al., 2024).*

Yang et al. integrated machine vision and UAV remote sensing technologies to collect visible-light images of corn during the tasseling stage. To construct a dataset and enhance model robustness, they employed the Segment Anything Model (SAM) for semi-automatic annotation and applied image augmentation techniques to simulate environmental variations. The study improved the YOLOv5 framework by introducing the lightweight MobileNetV3 network to reduce parameters and optimizing the network architecture for accurate detection of missed tassels. Experiments demonstrated that this method can automatically identify missed female tassels in the field, effectively evaluate detasseling performance, and provide precise location guidance for follow-up removal operations *(Yang et al., 2026)*.

Computer vision technology plays a central role in image recognition, and deep learning-based object detection algorithms (such as Faster R-CNN, SSD, and the YOLO series) have been widely applied to corn tassel recognition *(Duangpapeng et al., 2018; Alzadjali et al., 2021; Niu et al., 2024)*. Researchers train models using large, annotated datasets of tassel images, enabling the models to learn key information about tassel appearance, color distribution, and texture features. The trained models can then accurately identify tassels in new images captured by UAVs, providing reliable, high-throughput information on tasseling status for breeders *(Qi et al., 2025)*. However, the recognition accuracy of such models for small-target tassels remains insufficient, and their algorithmic performance requires further optimization.

Optoelectronic sensing recognition technology

Gu et al. designed an infrared detection-based corn detasseling machine, as shown in Figure 2. The machine mainly consists of a frame, a lifting device, a detasseling device, and an infrared detection unit. Its core innovation lies in the integration of an infrared detection unit in front of the detasseling unit, which contains multiple sets of infrared sensor pairs for precisely locating the height of the tassels. During field operation, when the top of the corn plant interrupts the optical path of the infrared sensor pairs, the control mechanism adjusts the working height of the hydraulic detasseling device in real time based on multiple height signals, thereby achieving precise alignment and adaptive control of the detasseling position *(Gu et al., 2013)*.

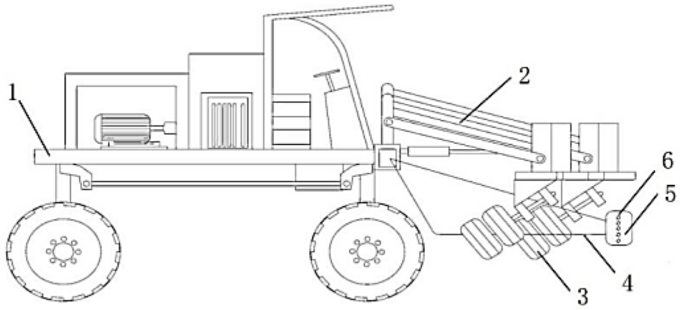

Fig. 2 - Infrared-guided corn detasseling machine *(Gu et al., 2013)*
1. Frame; 2. Lifting mechanism; 3. Profiling mechanism; 4. Connecting rod; 5. Infrared detection unit; 6. Infrared sensor

Liu et al. developed a height-adaptive corn detasseling device, as shown in Fig.3. The device primarily consists of a detasseling bracket and a control module. Two detasseling discs are mounted on the bracket, which is also equipped with a bracket hydraulic cylinder and a hydraulic cylinder for the sensor support rod. A reflector mechanism and a photoelectric sensor mechanism are installed at the front end of the bracket. During operation, the photoelectric sensor continuously detects tassel height and transmits the signal to the control module. The control module then actuates the bracket hydraulic cylinder to extend or retract, thereby adjusting the working height of the detasseling discs and profiling rollers. This enables the device to adapt to variations in corn tassel height during detasseling *(Liu et al., 2025)*.

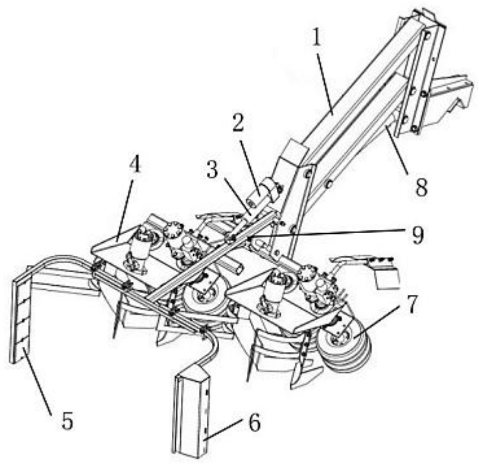

Fig. 3 - Height-adaptive corn detasseling header *(Liu et al., 2025)*
1. Frame; 2. Control module; 3. Hydraulic cylinder for the photoelectric-sensor support rod; 4. Profiling disc; 5. Reflector mechanism; 6. Photoelectric sensor mechanism; 7. Profiling roller; 8. Bracket hydraulic cylinder; 9. Profiling bracket

Wang et al. designed a single-row profiling and lifting mechanism for corn detasseling, as shown in Fig.4. The device mainly consists of a hydraulic lifting cylinder, a parallel four-bar linkage, a hydraulic motor, and photoelectric sensors. The photoelectric sensors are installed at the front of the frame on both sides of the sensor mounting bracket. The detasseling wheels are mounted behind the sensors and connected to an electric push rod. The entire detasseling assembly is connected to the parallel four-bar linkage, whose vertical movement is controlled by the hydraulic cylinder. A displacement sensor is mounted on the hydraulic cylinder and connected to the piston rod to monitor changes in piston displacement and convert them into pulse signals. Based on the signals received from the photoelectric sensors and the displacement sensor, the controller regulates the extension and retraction of the hydraulic cylinder and electric push rod. This enables the detasseling unit to follow variations in tassel height and perform adaptive detasseling *(Wang et al., 2015)*.

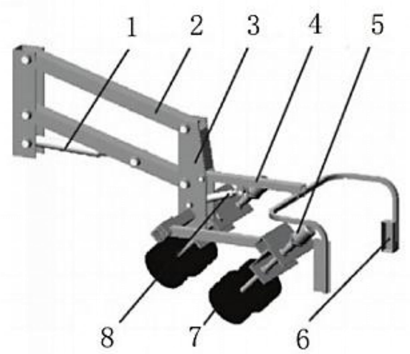

Fig. 4 - Single-row profiling and lifting mechanism for corn detasseling *(Wang et al., 2015)*
1. Hydraulic cylinder; 2. Parallel four-bar linkage; 3. Detasseling-wheel mounting bracket; 4. Sensor mounting bracket; 5. Hydraulic motor; 6. Photoelectric sensor; 7. Detasseling wheel; 8. Electric push rod

KEY TECHNOLOGIES FOR MECHANIZED DETASSELING

Existing mechanized detasseling technologies can be classified into two categories according to the removal method: extraction-type and cutting-type systems. Extraction-type detasseling commonly uses rotating wheels, belts, or rollers to grip and pull the tassel, together with a portion of the upper stem and leaves, from the corn plant through a clamping and pulling action *(Costa et al., 2019)*. Cutting-type detasseling primarily uses reciprocating or rotating blades to remove the tassel and portions of the attached upper stem and leaves through a shearing action *(Zou et al., 2020)*.

Cutting-Type Detasseling Technology

Research on cutting-type corn detasseling technology began in developed countries as early as the 1970s. Gildersleeve et al. designed a clamping-and-cutting detasseling device, as shown in Fig.5. The device mainly consisted of a frame, hydraulic motor, flexible drive shaft, drive chain, fixed blade, clamping wheels, and related components. During operation, the hydraulic motor transmitted power through the flexible drive shaft and drive chain to a pair of clamping wheels, causing them to rotate in the same direction. Under the force of a tension spring, the left clamping wheel was pressed against the lower portion of the right clamping wheel, thereby creating frictional contact between them. As the machine advanced, corn plants were guided toward the center by a crop divider and entered the contact region between the clamping wheels. The tassels were then cut by the combined action of the clamping wheels and the fixed blade *(Gildersleeve et al., 1973)*.

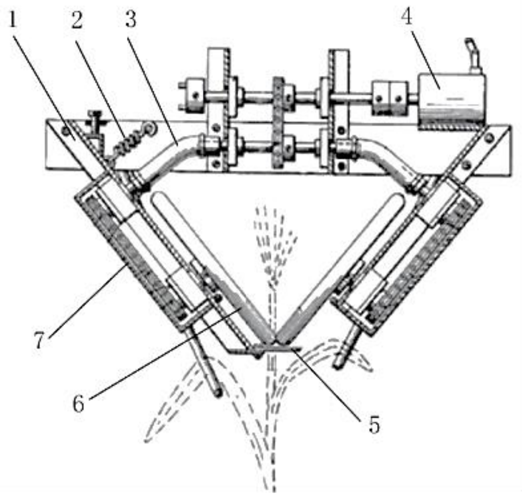

Fig. 5 - Clamping-and-cutting detasseling device *(Gildersleeve et al., 1973)*
1. Frame; 2. Tension spring; 3. Flexible drive shaft; 4. Hydraulic motor; 5. Fixed blade; 6. Clamping wheel; 7. Drive chain

Meiners et al. developed a horizontal cutting-type detasseling device, as shown in Fig.6. The device mainly consists of a drive belt, blades, guide rods, a crop divider, guide plates, and related components. During operation, corn plants are gathered toward the center by the crop divider and guided into the space formed between adjacent guide rods or between a guide rod and the protective shield. The tassels are then cut by blades arranged in a linear configuration. A notable feature of this device is that the multiple guide rods not only guide the plants but also help prevent leaves from entering the blade cutting zone, thereby reducing leaf damage and loss *(Meiners et al., 1973)*.

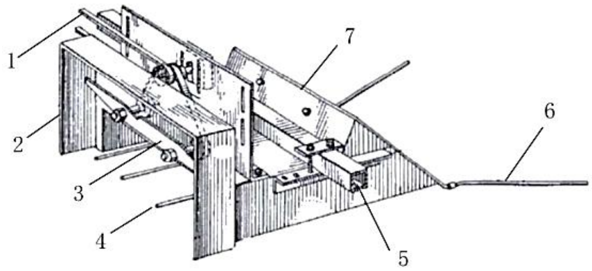

Fig. 6 - Horizontal cutting-type detasseling device (Meiners et al., 1973)

1. Drive belt; 2. Protective shield; 3. Blade; 4. Guide rod; 5. Frame; 6. Crop divider; 7. Guide plate

Grandinetti et al. designed an airflow-assisted corn detasseling device, as shown in Fig.7. The device mainly consists of a paddle wheel, a crop divider, air ducts and nozzles, an arcuate backing plate, and related components. During operation, the drive shaft rotates the paddle wheel to generate airflow, which is directed through the ducts and nozzles to separate the upper leaves. After the plants leave the airflow zone, the vertical plates maintain the leaves in the separated position. The tassel then enters the space between the two vertical plates and is snapped or cut off through the combined action of the paddle wheel, its blades, and the arcuate backing plate. The airflow system and vertical plates effectively separate the tassel from the upper leaves and prevent leaf rebound, thereby reducing damage to the upper leaves of the corn plants *(Meiners et al., 1990)*.

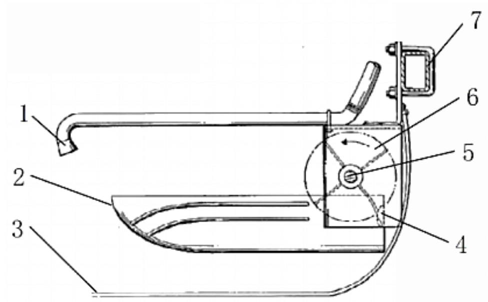

Fig. 7 - Airflow-assisted cutting-type detasseling device *(Meiners et al., 1990)*

1. Air duct and nozzle 2. Vertical plate 3. Crop divider 4. Arcuate backing plate 5. Drive shaft 6. Paddle wheel 7. Frame

Based on the phenotypic characteristics of corn plants and the principles of manual detasseling, Song et al. proposed a downward cutting-and-rotating detasseling method designed to reduce damage to the leaves surrounding the tassel. To implement this method, they developed a compact corn detasseling device comprising an RGB camera, left and right gripping mechanisms (Claw-L and Claw-R), a sliding mechanism, and a rotating mechanism. The complete operating sequence of the device is illustrated in Fig.8. Field experiments showed that the device achieved a tassel-removal success rate of 88.33% *(Song et al., 2024)*.

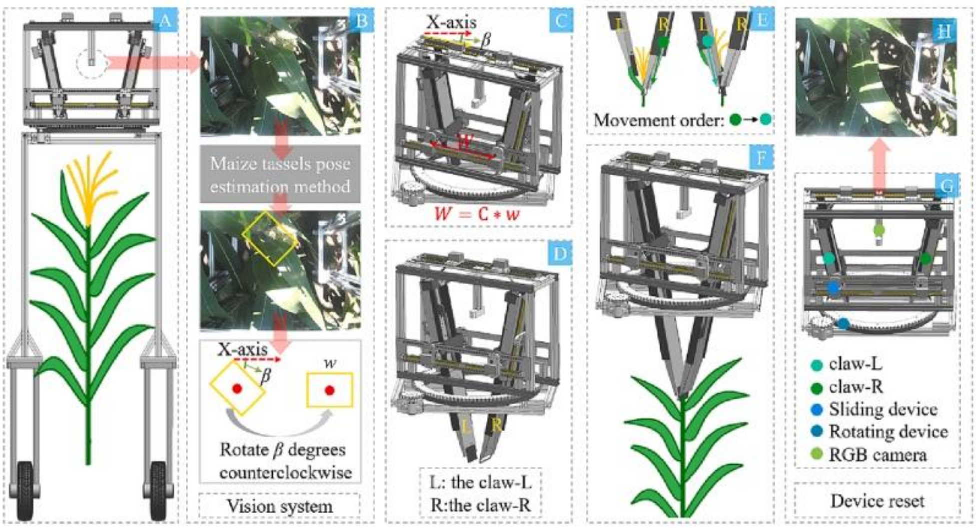

Fig. 8 - Operating sequence of the corn detasseling device *(Song et al., 2024)*

A. Schematic of the device during operation; B. Vision system; C. Movement of the device to the specified angle and position; D. Movement of Claw-L and Claw-R to the specified positions; E. Movement sequence of the two claws during detasseling; F. Device configuration upon completion of detasseling; G. Return of the device to its initial position; H. Removed corn tassel

Extraction-Type Detasseling Technology

In 1970, *Spry et al.* developed a belt-type extraction detasseling device, as shown in Fig.9. The device mainly consisted of a pressure wheel, a hydraulic motor, a leaf-pressing roller, and related components. During operation, as the implement advanced, corn plants were guided toward the center by a crop divider. Under the continuous action of the leaf-pressing roller, the tassel was separated from the surrounding leaves and then entered the gripping zone formed by two elastic belts. The tassel was gradually pulled from the plant and either discharged onto the ground or collected. A helical metal strip was mounted on the surface of the leaf-pressing roller to improve its gripping and downward-pressing performance *(Spry et al., 1970)*.

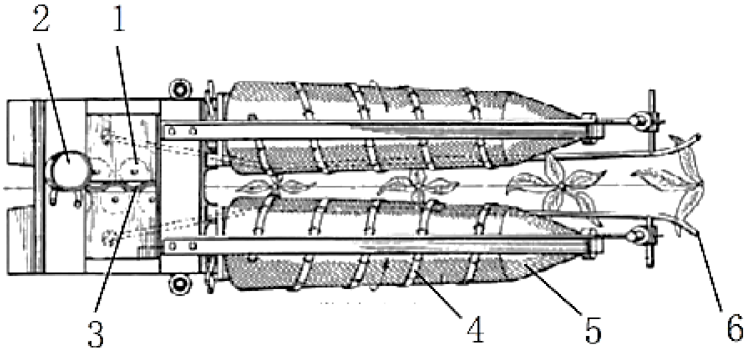

Fig. 9 - Belt-type extraction detasseling device *(Spry et al., 1970)*

1. Compression wheel; 2. Hydraulic motor; 3. Elastic belt; 4. Helical metal strip; 5. Leaf-pressing roller; 6. Crop divider

Kenneth et al. designed a pneumatic-wheel extraction detasseling device, as shown in Fig.10. The device primarily consists of a main frame, a support frame, a hydraulic motor, a drive shaft, a driven shaft, pneumatic rubber wheels, and related components. During operation, the drive wheel and driven wheel rotate in opposite directions, gripping and pulling the corn tassel together with a portion of the attached upper stem and leaves. The removed material is then discharged into the interrow space. The pneumatic rubber wheels provide flexible gripping, thereby improving the adaptability of the detasseling mechanism to variations in tassel size and position. In addition, the tread pattern on the wheel surfaces enhances gripping performance *(Kenneth et al., 1970)*.

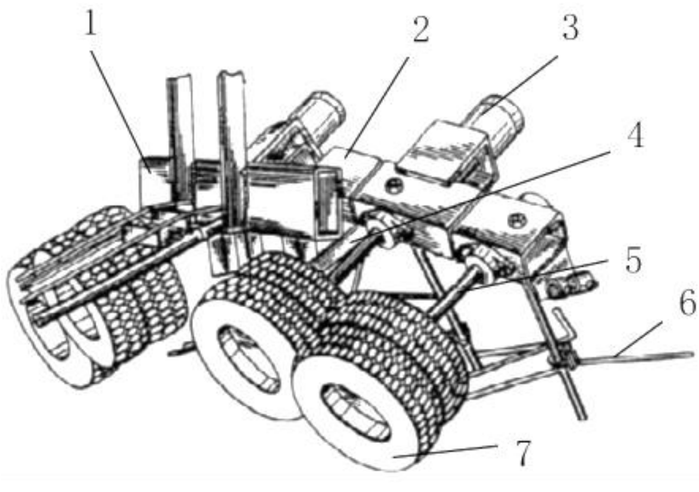

Fig. 10 - Pneumatic-wheel extraction detasseling device *(Kenneth et al., 1970)*

1. Frame; 2. Fixed frame; 3. Hydraulic motor; 4. Drive shaft; 5. Driven shaft; 6. Crop divider; 7. Pneumatic rubber wheel

Bourgoin developed a flexible-disk extraction detasseling unit, as shown in Fig.11. The unit mainly consists of a crop divider, two flexible disks, an opening roller, a pressure roller, and related components. During operation, as the detasseling unit advances, corn plants are guided toward the center by the crop divider and enter the V-shaped space formed by the two flexible disks. Under the combined effects of disk rotation and forward travel, the plants move progressively into the contact zone, where the gap between the disks gradually narrows until the disks come into full contact. The tassel is then firmly gripped by the flexible disks under the action of the pressure roller, pulled from the plant, and discharged forward. A limitation of this design is that the removed tassels may become entangled with or remain caught on the corn plants.

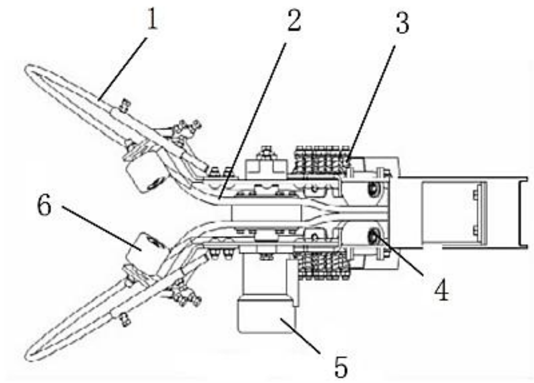

Fig. 11 - Flexible-disk extraction detasseling unit

1. Crop divider; 2. Flexible disc; 3. Compression spring; 4. Opening roller; 5. Hydraulic motor; 6. Pressing roller

DEVELOPMENT STATUS OF MECHANIZED DETASSELING EQUIPMENT FOR CORN SEED PRODUCTION

Mechanized Detasseling Equipment Developed Outside China

Research on mechanized detasseling equipment for corn seed production began relatively early in other countries. In 1937, the first mechanized corn detasseling machine was developed in the United States. As shown in Fig.12, the machine featured a high-clearance chassis equipped with six operator platforms and supported by three ground wheels, allowing it to travel slowly between corn rows. However, tassel removal was still performed manually by workers standing on the platforms. Therefore, the machine essentially provided mechanized transport and elevation for manual detasseling rather than fully mechanized tassel removal *(Seeber et al., 1937)*. By 1950, a second-generation detasseling machine had been developed, as shown in Fig. 13 *(Hagle et al., 1950)*. Compared with the earlier model, it provided improved travel stability, operator safety, and field efficiency. Nevertheless, because the detasseling operation still depended heavily on manual labor and the level of automation remained limited, the machine was not widely adopted.

Fig. 12 - Early mechanically assisted corn detasseling machine *(Seeber et al., 1937)*

Fig. 13 - Second-generation mechanically assisted corn detasseling machine *(Hagle et al., 1950)*

In recent years, various corn detasseling machines have been widely adopted in Europe, the United States, and other regions as alternatives to manual labor. These machines are technologically mature, highly efficient, and adaptable to different field conditions. Representative models include the 204SP and DTB series manufactured by Hagie in the United States; the TS4, 5175, and 5180 manufactured by Oxbo in the United States; the PDF752D manufactured by Big John in the United States; the BD864 manufactured by Bourgoin in France; the FALCON 140 manufactured by Frema in France; and the S series manufactured by Castrix in Italy. The Hagie 204SP is one of the earliest commercially available self-propelled corn detasseling machines, as shown in Fig.14. It uses a four-wheel hydrostatic drive system and has a chassis ground clearance of 193 cm. Its track width can be adjusted from 214.6 to 304.8 cm, allowing operation at common corn row spacings of 51–76 cm. Depending on operational requirements, the front of the machine can be equipped with either extraction-type or cutting-type detasseling units. The operating height of these units can be adjusted over a range of 0–167.6 cm, and the machine can be configured to operate on 4 to 18 rows, in even-numbered configurations *(Ma et al., 2012)*.

Fig. 14 - Hagie 204SP self-propelled corn detasseling machine
(Ma et al., 2012)

Fig. 15 - Hagie DTB-series corn detasseling machine

In addition, the Hagie DTB-series corn detasseling machines have been well received because of their operational versatility. Machines in this series can also be readily converted for use as self-propelled sprayers, as shown in Fig. 15. Several other representative corn detasseling machines are presented in Fig.16, and their principal performance parameters are summarized in Table 1.

Fig. 16 - Representative corn detasseling machines
a) Oxbo TS4; b) Oxbo 5175; c) Big John PDF752D; d) Bourgion BD864; e) Frema FALCON140; f) Castrix S4C

Table 1

Key specifications of representative corn detasseling machines developed outside China

Model	Rated power	Row spacing	Track width	Ground clearance	Number of rows	Turning radius	Field capacity	Detasseling rate
	[kW]	[cm]	[cm]	[mm]	-	[m]	[ha/h]	[%]
Oxbo TS4	95.61	60 ~ 80	6000 ~ 8000	1900	12/16	-	5.8 ~ 7.7	≈95
Oxbo 5175	127	60 ~ 76	2290 ~ 3000	1830	12	4.8 ~ 8.7	-	≈95
PDF752D	92	40 ~ 90	2000 ~ 2600	1850	8	4.3 ~ 5.6	2 ~ 2.5	≥92
BD864	82	-	2000 ~ 3000	2100	4/6/8/9	-	-	≥90
FALCON140	103	-	2000 ~ 2600	2000	6/8/9/12	5.5 ~ 7.0	3.5 ~ 5.6	≥90
S4C	55.4/57.6	60	1600 ~ 2200	1600	4/6	3.4 ~ 4.8	1.8 ~ 2.3	≈95

Corn detasseling machines developed outside China are generally technologically mature. Their typical configurations include a self-propelled power unit, hydraulically driven working components, and cutting-type or pneumatic-wheel extraction-type detasseling mechanisms. These machines also commonly incorporate intelligent technologies, such as optical sensing for tassel detection and automatic height adjustment, to improve operating precision. However, this high level of technological integration also leads to substantial equipment costs, which typically exceed RMB 1 million per unit *(Liu et al., 2025)*. Such high prices significantly limit their adoption by farms in China, which generally operate on a smaller scale.

Mechanized Detasseling Equipment Developed in China

Research on corn detasseling machines in China began relatively late. During the early stages, development efforts focused primarily on importing and adapting foreign designs. One representative achievement was the 3QXZ-6 corn detasseler, developed by the Chinese Academy of Agricultural Mechanization Sciences in 2016. However, because of limitations in technological maturity and market adaptability at that time, the machine was not produced on a large scale *(Wang et al., 2016)*. At present, the corn detasseling machines that have entered mass production and practical use in China are mainly manufactured by Jiuquan Ouke Seed Machinery Co., Ltd. Representative models include the OK104-3CX and 3CX-6A corn detasseling machines, shown in Figs. 17 and 18, respectively. Together with the 3QXZ-6, these machines use both cutting-type and pneumatic-wheel extraction-type detasseling mechanisms. Their principal performance parameters are summarized in Table 2 *(Xu et al., 2015; Zhu et al., 2015; Feng et al., 2024)*.

Fig. 17 - OK104-3CX

Fig.18 - 3CX-6A

Table 2

Key specifications of three corn detasseling machines developed in China

Model	Rated power	Row spacing	Drive configuration	Track width	Ground clearance	Number of rows	Turning radius	Field capacity	Detasseling rate
	[KW]	[cm]	-	[cm]	[mm]	-	[m]	[ha/h]	[%]
3QXZ-6	88.2	60	self-propelled	2000～2600	1800	4/6	-	-	≈87.7
OK104-3CX	160	-	self-propelled	1900～2300	1900～1960	8/12	6.6	1～2.3	≥85
3CX-6A	120	-	self-propelled	1900～2300	1900	4/6	3.2～4	0.8～1.5	≥85

In July 2024, a fully electric corn detasseling robot independently developed by Xinjiang Jiuyu Technology Co., Ltd. was introduced and deployed for field operations in Guangming Village, Ergong Town, Changji City, as shown in Fig. 19. The robot integrates the BeiDou Navigation Satellite System with LiDAR point-cloud data and AI-based image-recognition algorithms to generate precise operating paths in real time. During operation, it detects the positions of the leaves and tassels and autonomously determines the required lowering distance of the detasseling actuators. The robot can accommodate corn plants ranging from 1.5 to 2.3 m in height, provides millimeter-level positioning accuracy, and achieves a tassel-removal rate of 90%. It can detassel four rows in a single pass, with a field capacity of 0.47–0.74 ha/h and an energy consumption of approximately 6 kWh/ha. Compared with conventional methods, the robot can reduce labor costs by more than RMB 40 per *mu* and substantially shorten the detasseling period. The deployment of this machine represents an important step toward the intelligent automation of detasseling operations in China's corn seed-production industry.

Fig. 19 - Fully electric corn detasseling robot

Corn detasseling equipment developed in Europe and the United States has established a relatively mature technological system characterized by high-powered self-propelled chassis, hydraulically driven cutting- or extraction-type working units, and basic optical height-profiling systems. Although this system provides high field efficiency, it is also associated with high equipment costs and limited adaptability to diverse agronomic practices. By contrast, although technological development in China began later, substantial progress has been made in lightweight machinery for small- and medium-sized fields and in intelligent recognition technologies based on machine vision and photoelectric sensing. Notable advances have also been achieved in fully electric drive systems and intelligent detasseling robots integrating the BeiDou Navigation Satellite System with AI-based technologies.

FACTORS LIMITING THE MECHANIZATION OF CORN DETASSELING

(1) Corn detasseling machinery continues to face important technical limitations. Although mainstream machines developed in China and other countries generally achieve satisfactory detasseling performance, they often fail to meet seed-purity requirements in a single pass. As a result, growers must rely on manual follow-up removal or repeated machine passes to eliminate missed tassels. The effective detasseling window is only 7–10 days. Manual inspection and removal are labor-intensive and inefficient and may not consistently ensure the required quality. Repeated passes by ground-based machinery, however, substantially increase operating costs and may cause soil compaction and crop damage. Therefore, the efficient and accurate detection and removal of missed tassels remains a central challenge in improving the quality and efficiency of detasseling operations.

(2) The requirements of agricultural machinery and agronomic practices remain insufficiently coordinated. The absence of unified standards for planting parameters, including row spacing and female-to-male row configuration, increases the difficulty of mechanized detasseling in corn seed production. China's principal corn seed-production areas are concentrated in regions such as Gansu and Xinjiang. In Gansu, however, fields are relatively fragmented, and plots larger than 30 *mu* account for less than 5% of the total cultivated area. This limits the ability of large detasseling machines to fully realize their field-efficiency advantages. In addition, the large number of corn varieties used for seed production results in substantial differences in tassel height and attachment strength. Even within the same field, individual plants may vary in height and morphology because of differences in seed vigor, water and nutrient availability, and localized soil conditions. These factors place greater demands on the adaptability and control accuracy of detasseling machinery.

(3) Mechanical damage caused by detasseling operations remains a significant problem. Manual detasseling can generally remove tassels from female parent plants with minimal damage to other plant tissues. In contrast, mechanical detasseling relies primarily on cutting or roller-clamping extraction mechanisms, which may tear or crush the leaves surrounding the tassel. This problem is particularly serious in varieties with relatively few leaves above the ear, because damage to these leaves can directly reduce photosynthetic capacity and impair assimilate transport, ultimately decreasing seed yield. Reported data indicate that mechanical detasseling may reduce the yield of such sensitive varieties by approximately 15%.

(4) Growers' acceptance of detasseling machinery remains relatively low. On the one hand, imported machines involve high purchase and maintenance costs, whereas the operating window for corn detasseling is short. Consequently, annual machine utilization is low and the investment payback period is long. On the other hand, although labor costs continue to rise, reaching approximately RMB 300 per worker per day, the advantages of existing machinery in terms of field efficiency and cost-effectiveness are not yet sufficiently pronounced. This is particularly true under complex agronomic conditions, where machine performance may remain unstable. In addition, traditional production practices continue to influence decision-making in some rural areas. Growers may therefore be cautious about adopting new technologies and may prefer to rely on experienced workers for detasseling operations.

OPTIMIZATION STRATEGIES FOR MECHANIZED CORN DETASSELING

(1) Promote the development of intelligent and precision detasseling equipment

Future research and development should focus on improving the overall performance of detasseling equipment. The primary objective should be to balance a high tassel-removal rate with a low plant-damage rate by minimizing mechanical damage to the leaves while maintaining effective detasseling performance. Efforts should also focus on improving equipment adaptability. Dedicated machine series and modular configurations should be developed for different production systems, including large-scale operations on expansive fields and fragmented production on small plots. The long-term goal is to develop a new generation of intelligent, precision detasseling equipment. Achieving this goal will require breakthroughs in key technologies, including intelligent tassel-recognition algorithms, high-precision height-profiling actuators, and adaptive control systems for complex field terrain. These developments are expected to address persistent limitations such as high plant-damage rates and large turning radii.

(2) Promote closer integration of agricultural machinery and agronomic practices

Efficient and stable mechanized detasseling requires coordinated optimization of agronomic standards and variety development. First, standardized planting protocols should be established and promoted to unify key agronomic parameters, including row spacing and female-to-male row ratios, thereby creating favorable conditions for mechanized operations. Second, breeding programs should target varieties with uniform plant height and ear position, together with tassel characteristics suitable for mechanical removal. Such varieties would provide stronger biological and agronomic support for mechanized detasseling. Finally, collaboration between agricultural machinery engineers and agronomists should be strengthened. A permanent, integrated mechanism for research, development, field validation, and extension should be established so that agronomic requirements guide machine design and machinery performance supports agronomic objectives. This coordinated approach will promote the systematic advancement and sustainable development of full-process mechanization in corn seed production.

(3) Strengthen demonstration, extension, and service support

First, the systematic development of high-standard farmland should be promoted. Land consolidation, field leveling, supporting farm roads, and improved field-layout planning can create more favorable operating conditions for mechanized detasseling and, ultimately, full-process mechanization. Second, an effective demonstration and extension system should be established. Large-scale growers, specialized cooperatives, and other qualified organizations should be selected and supported in establishing demonstration bases. Field comparison trials can then be used to clearly demonstrate the efficiency and economic benefits of mechanized detasseling, thereby increasing growers' awareness of and willingness to adopt the technology. Finally, new models of agricultural service provision should be actively explored. Cooperatives, agricultural enterprises, and other service providers should be encouraged to offer specialized contract detasseling services. Large-scale service operations can improve machinery utilization, spread investment and operating risks across multiple users, and support the development of a sustainable mechanism for technology adoption and expansion.

CONCLUSIONS

This paper systematically reviews and compares the historical development, current technological status, and equipment characteristics of mechanized detasseling for corn seed production worldwide. At present, the wider adoption of mechanized detasseling remains constrained by several factors, including insufficient single-pass tassel-removal rates, poor coordination between agricultural machinery and agronomic practices, high plant-damage rates, and limited economic viability. However, with continued advances in artificial intelligence, robotics, and precision agriculture, detasseling technology is expected to become increasingly intelligent, precise, and integrated. These developments may substantially reduce reliance on manual labor and create the conditions for mechanized detasseling to replace most, or potentially all, manual operations in corn seed production.

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