

Research Progress and Prospects of Ridge Forming and Film Covering Technology and Equipment

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Abstract

In China, due to the serious shortage of water resources, the sustainable development of agriculture has been greatly restricted, in order to improve the utilization of water resources and enhance crop yield, ridging mulching machinery has been widely used in agricultural production. This paper analyzes the development and current situation of ridging and mulching equipment, and analyzes the typical ridging and mulching equipment at home and abroad, and summarizes the advantages and disadvantages of the representative models of rotary, disc, and spade-type ridging and mulching machines. The advantages and disadvantages of the representative models of rotary disc and spade type ridging and mulching machines are summarized, and the problems of the current ridging and mulching machines are summarized, such as the lack of universality of the machine, the low degree of integration of the design and agronomy, the low level of intelligence, and the use of the traditional PE film that causes environmental pollution. The study is expected to provide guidance to promote the further development of ridging and mulching equipment and to alleviate China's water shortage.

Keywords

Ridge Laminating Machine; Water Utilization; Technical Regulations; Operating Efficiency.

1. Introduction

China's water resources are scarce, and currently the per capita water resources in China are less than one-third of the world average. With the rapid development of agriculture and industry in China and the rapid growth of population, water resources in agricultural production are also facing a severe crisis. About 63% of China's total annual water use is for agriculture [3], as shown in Fig. 1. According to statistics, the average grain yield per cubic meter of irrigation water in China is about 1 kilogram, while advanced countries in the world (such as Israel) have an average grain yield of 2.5-3.0 kilograms per cubic meter of irrigation water. China's agricultural water-saving irrigation area accounts for 35% of the effective irrigation area, while countries such as the UK, Germany, France, Hungary, and the Czech Republic have all achieved a water-saving irrigation area ratio of over 80% [4,6]. In order to increase crop yield, groundwater is often extracted for irrigation during crop

irrigation. Excessive extraction of groundwater can cause a decrease in groundwater level and exacerbate land desertification. Due to outdated irrigation technology and water management, water resources are severely wasted [8], and the development of ridge mulching technology is an important way to alleviate water resource waste in China.

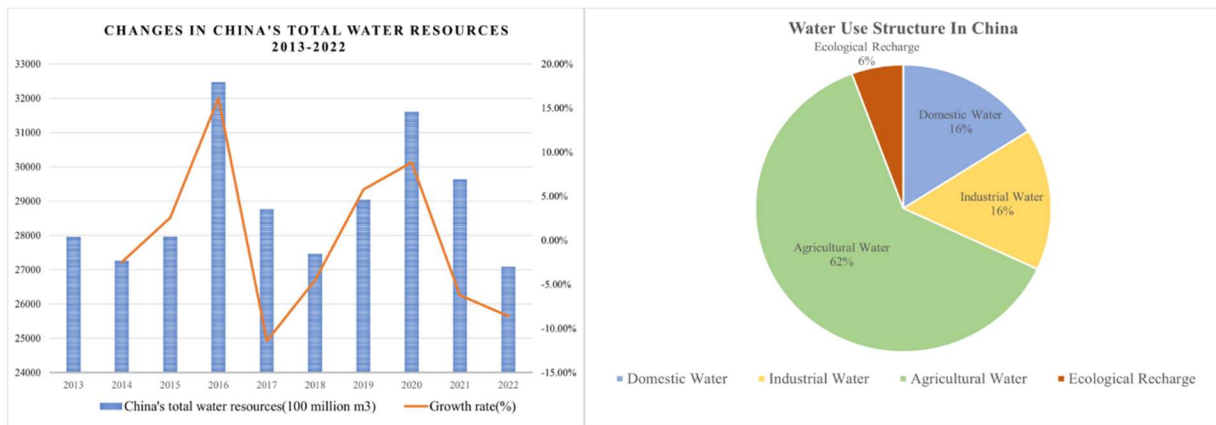


Fig. 1 The total amount and composition structure of water resources in China

Ridge mulching cultivation is a widely used agricultural cultivation technique in North China, Northeast China, and other regions. It is often used for the cultivation of corn, soybeans, potatoes, and taro crops [9,10], which can provide more light to crops, increase surface temperature, and reduce soil erosion [9,11]. The combined effect of these functions greatly improves the yield and quality of crops. Research by Zhou Yongjin and others has shown that mulching treatment can increase the rate of dry matter accumulation after sowing at a higher rate than the control group [12]. During the growth cycle of corn, ridge mulching technology can increase the average soil moisture content from 0 to 60 cm by about 1.81% to 2.12% [13], playing a significant role in increasing yield. The application of ridge mulching machines has improved modern agricultural production efficiency and labor utilization [14]. A livestock powered mulching machine can increase efficiency by 5 to 8 times, while a tractor driven mulching machine can increase efficiency by 5 to 15 times or even more [15,17]. The mechanical mulching machine adopts an automated control system, which can control parameters such as coverage speed, mulching width, and mulching thickness through precise settings [18], So as to ensure the uniformity and accuracy of the film coating, fully meeting the requirements of the operation. In addition, mechanical lamination can save plastic film [19] and reduce costs. With the continuous development and promotion of agricultural technology, mechanical film covering will become the trend of future agricultural production.

This article reviews the development of typical ridge mulching machines at home and abroad, analyzes the structural characteristics and applicable environments of these machines, and proposes comprehensive application suggestions suitable for China's ridge mulching technology. It is expected to provide reference for further development of ridge mulching technology research, alleviate agricultural water crisis, and make efforts to control residual film hazards.

2. Current Research Status at Home and Abroad

2.1 Current Research Status of Domestic Ridge Forming and Laminating Machines

In the 1960s, China began researching ridge forming and film covering machinery by introducing and absorbing equipment from Japan and South Korea. In recent years, with the progress of agricultural technology and technology, as well as the implementation of national agricultural machinery purchase subsidies, large-scale ridge forming and film covering machinery has been widely promoted in northern China [20]. How to design the 1QL-70A ridge forming machine, as shown in Fig. 2, This model is mainly designed for wheat cultivation in the irrigated agricultural area of the Hexi Corridor.

It adopts a combination of ridge forming device and cylindrical compaction roller for operation, which can improve the ridge forming and compaction effects. The original plow head device has been improved and optimized to improve the efficiency and quality of land plowing, making the ridge shape more neat and standardized, and increasing the soil water retention and moisture retention capacity. At the same time, this model is equipped with an adjustable ridge depth adjustment device, which can be flexibly adjusted according to the needs of different plots and crop growth [21].



Fig. 2 Model YS-1GVFM-125A Fertilizer Mulching and Mulching Machine

Shandong 1ZKNP-125 rotary ridging machine, the machine can adjust the ditch width before operation, so that the ridge distance is 70-125 cm, the ridge height after ridging is 15-20 cm, the machine is equipped with a hydraulic bias device, the machine can be offset left and right during operation, the maximum offset distance is 30 cm, and the supporting power is more than 40kw. The machine can complete rotary tillage, ridging and suppression operations at one time [22].

At the same time, some small trenching and ridging machines are also applied in sticky soil in the south, such as Chen Zhihou's research and design of YS-1GVFM-125A tobacco field mulching machine. This mulching machine can simultaneously complete rotary tillage and ridging, stirring cage fertilization, and mulching soil operations. It is powered by an 11.03-16.17 kW diesel engine, with a ridge height of 20-30 cm and a ridge width of 60-80 cm. This machine innovatively uses the method of reverse rotary tillage for ridging, adopting a left and right double helix structure, with 6 ridging plows installed on each side. The plows rotate to break the soil and transport it to the middle to form a ridge, changing the traditional ridging method (ridging by pulling the plow blade) and reducing soil resistance during operation [23]. The ridge shaping plate presses the soil broken by the trenching device into a stepped shape, and the film laying device spreads the film flat on the ridge surface through the film pressing flat roller. The improvement of the ridging structure and film covering device of this machine enables it to better adapt to the humid soil environment in southern regions, providing an improvement plan for the ridging and film covering machine in southern paddy fields. However, the ridging device and film hanging mechanism of the machine are packaged as a whole, which makes it impossible to adjust the height and width of the ridging. Moreover, due to the use of a reverse rotation ridging device, the machine will generate significant vibration during operation, and in severe cases, it can lead to inaccurate laying of the plastic film and even tearing of the film.



Fig. 3 Model YS-1GVFM-125A Fertilizer Mulching and Mulching Machine

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In 2016, Sui Xiuxu developed a double ridge four row ridge mulching integrated machine suitable for sweet potato cultivation and improved the ridge forming mechanism in the mulching machine. The machine uses a double spiral inclined ridge forming blade type ridge forming device [24]. Through dynamic analysis of the ridge forming device of the machine, a dynamic model of the machine's soil transportation was established, and the relevant parameters of the ridge forming mechanism were calculated. However, the machine did not consider the influence of soil adhesion on film coating, and cannot meet the operational requirements in clay environments. Therefore, the machine does not have universality. The film pressing roller mechanism and film pressing machine mechanism of this model lack elastic buffering elements, and the film coating process lacks flexibility. There are still problems such as rough workmanship and single function of the machine.

2.2 Current Research Status of Foreign Ridge Forming and Laminating Machines

The research on ridge forming and film covering technology was relatively early and widely used abroad. Japan began relevant research in 1948 and is the earliest country in the world to implement ridge mulching and seeding. Its field machinery, such as ridge mulching and seeding machines, and ridge arching and greenhouse machines, have formed a scale and commercialization. Ridge mulching, fertilization and seeding, and greenhouse setting are carried out simultaneously to achieve maximum efficiency. At present, there are mainly two types of ridge forming and film covering machines abroad. One type is represented by Europe and America. The ridge forming and film covering machines are aimed at large farms and pay attention to the application of advanced technology, with the goal of minimizing labor input and fully utilizing the maximum performance of agricultural machinery. The representative machines include PERFECTA-140 vegetable planting ridge machine developed by HORTECH company in Italy and 2370 ridge covering machine from Rain FloIrrigation company in the United States. Another type is represented by countries such as Japan and South Korea, whose ridge forming and film covering machines are mainly miniaturized and suitable for small and medium-sized plots. Representative machines include the NSPU-68 from Kubota in Japan and the KG-PH9000 sowing and film covering machine from KOMachine in South Korea. These types of machines are usually equipped with low-power diesel engines and diesel engines as power sources, which have the characteristics of simple structure, small size, and flexible operation. However, they also have disadvantages such as single functionality and poor scalability. Taking the STF-110 series ridge forming and laminating machine of FORIGO company in Italy as an example, as shown in the figure, the CO There are multiple models under the Modus series, with a working width of up to 0.9 to 2.3 meters, mainly suitable for working environments with soft soil. This laminating machine has a high degree of functional integration, and can complete multiple processes such as ridge formation, film tension, film pressing, and soil covering in one go through the three-point suspension traction of the tractor [26]. The machine is equipped with a film tension adjustable clutch and a height adjustable film tensioning device, and is equipped with a bracket group that can be used in combination with other FORIGO machines, which can achieve the multifunctionality of the laminating machine.



Fig. 4 STF-110 series sowing and laminating machine

The Kangnong KG-PH9000 sowing and laminating machine developed by KOMANINE Company in South Korea is mainly used for small and medium-sized laminating operations. This model can complete multiple steps such as rotary tillage, ridging, sowing, mulching, and soil covering in one go. While mulching, it also completes the laying of drip irrigation belts. The machine can work for 8 hours to complete a work area of 99-165 acres [27]. The machine forms a wide ridge and can sow and drip two rows of crops on the same ridge surface. This not only ensures the quality and tightness of mulching, but also reduces early spring low-temperature freezing damage and summer high-temperature heat damage, At the same time, it reduces the amount of plastic film used.



Fig. 5 KOMACHINE (Korea) KG-PH9000 seeding and laminating machine

The PERFECTA-140 vegetable ridger developed by HORTECH in Italy can be adjusted from 5 to 20cm in height and 140cm in width. It is equipped with a tractor with a power of more than 40kw. It is suitable for large plain areas and can complete many operations such as soil breaking, ridging and fertilization in one go. The double-disc trenching operation was carried out. The double-disc trenching operation tilted inward in a figure of 8. The soil was deeply broken by the rotary tillage device, and the soil was thrown to the center of the ridge by centrifugal force to form the ridge body initially.



Fig. 6 HORTECH (Italy) PERFECTA-140 vegetable planter ridger

The Rain-FloIrrigation 2370 is a compact mulch machine that can handle 90 to 150 cm wide mulch, making it ideal for small and medium-sized fields. This model comes with an additional mulch roll holder for quick mulch replacement during continuous operations, and adjustable line marking equipment for seeding and drip irrigation operations. The plastic film tensioning roller is equipped with a brake device, which can adjust the tensioning force of the film during the film laminating process [29]. The machine has a compact structure, but the supporting drive device needs to meet more than 30 horsepower, so its overall working size is not reduced, and the machine can only be used for floor paving, without ridging function, and there are certain limitations in performance.



Fig. 7 Rain-FloIrrigation (USA) Company 2370 ridging mulch machine overall picture

BP480 single ridge and three ridge laminating machine developed by Kennco Manufacturing. As shown in Fig. 8, the machine adopts a whole-body welding fastening method instead of the traditional bolt connection, which can avoid the sliding and falling off of the parts caused by vibration when the ridging and laminating machine is working, and can adjust the height and width of the machine to adapt to different agricultural planting methods. Compared with other laminating machines, this machine can quickly switch two different types of mulching film at the same time, and its tensioning roller has the braking function, which can adjust the speed of the tensioning roller to improve the tensioning force of mulching film and improve the working quality of the machine [30]. However, the machine needs more traction, and also needs additional workers to control on the laminating machine, the degree of automation is low, and the heavy welding frame used in the fuselage also makes the model only suitable for work in large plain fields, when the work scope is small, the model lacks flexibility.



Fig. 8 BP480 model ridging and mulching machine

Overall, foreign ridge forming and film covering machines have developed earlier and their technical level is relatively mature. Due to their widespread application in environments with more flat and

wide ridge planting patterns, these tools are typically developed towards high horsepower and wide width. Considering the significant differences in crop cultivation, planting environment, land topography, and economic development between China and foreign countries, many foreign machines are not suitable for most of China's operating environments. Currently, the commonly used rotary tillage ridge and film covering machinery in China can basically meet the requirements, but there are still certain design flaws and weak adaptability to different operating environments.







3. Classification of Ridging Laminating Machines

There are various types and functions of ridge forming and laminating machines. According to the different power sources of the ridge mulching machine, it can be divided into manual traction type, walking tractor traction type, and four-wheel tractor traction type. Functionally, it can be divided into two categories: single type mulching machine and multifunctional mulching machine. The multifunctional mulching machine can complete functions such as rotary tillage, land preparation, ridging, and mulching in one go. According to the different structures of its ridge forming components, it can be divided into rotary, disc, and plow types.

3.1 Rotary Furrowing and Ridging Machine

Rotary trenching machine is a continuous excavating trenching machine (typical rotary ridging and laminating machine is shown in Table 1). The rotary furrow mulching machine is mainly composed of frame, transmission box, rotary tiller structure, film mulching device, suppression roller and other components, which can simultaneously meet the operation requirements of rotary tillage, land preparation, ridging, film mulching and film pressing [31,33]. During operation, the rotary tilling tool axis rotates the soil, the shaping device ridges the soil thrown by the rotary tilling, the film compacts the top of the ridge along the ridge surface, the film pressing wheel presses the film into the ditch opened by the trenching knife and pulls it horizontally, and the soil covering device covers the residual soil on the edge of the mulching film and compacts it. The rotary ridging and laminating machine has the advantages of simple structure, small model, good mobility, low working resistance, etc., which can basically meet the requirements of small farmland ditching operation, and is widely used. The disadvantage is that the transmission system is complex, which makes the power consumed when the power is transferred to the cutter head becomes larger and the working speed becomes slower. The manufacturing and assembly of the whole machine have higher requirements for the process [34]. The representative models of this kind of laminator are IMSLQ-40/80 ridging, film laying and fertilization combined machine, IMSLQ-40/80 ridging, film laying and fertilization combined machine can be used with 13.3 ~ 22.0kw small four-wheel tractor with rear power output shaft, large ridge width 70 ± 3 cm, height 13 ± 3 cm; Ridge width 40 ± 3 cm, height 10 ± 3 cm; Ridge spacing $(110 \sim 120) \pm 10$ cm; The soil covering width of the film edge is $8 \sim 10$ cm. The machine has a compact and reasonable structure, high production efficiency, and is suitable for cultivated plots, but its surface requirements are relatively high, and the soil moisture content is between 10% and 16%, otherwise the soil transport resistance is large. At the same time, the tightness of the conveyor belt is difficult to adjust [35]. 2BSQF- type soybean ridging fertilization and seeding machine, which is suitable for soybean, corn and other crops in Jiangsu Province and nearby areas. In order to ensure the stable yield and high yield of soybeans after planting, the moving speed was set at 1 m/s, the IT245 type rotary tillage tool was selected, and the rotating radius was 245 mm. Ridge height can be adjusted within 200 ~ 250 mm [36].

Table 1. Typical Chinese rotary trenching and ridging equipment






Number	Model	Equipment pictures	Characteristics	Applicable scenarios
1	Celery planting machine		The celery planting integrated machine developed by Nanjing Agricultural Mechanization has a flat bed height of 10 cm, a bed width of 120 cm, a plastic film width of 160 cm, a plant spacing of 15 cm, and a sand cover thickness of 1-1.5 cm. Solved the integration problem of ridge forming, sand covering, and film covering equipment.	Field agriculture
2	GF400+ Rotary ridger		The GF400+rotary tiller ridging machine can complete the process of rotary tiller breaking soil, ridging and fertilization in one go, with a working width of 3600 mm. It adopts an S-shaped rotary tiller blade, suitable for neutral or cohesive soil, equipped with a 600 kg fertilization box, and can complete four ridging operations in a single operation. At the same time, two drip irrigation belts can be installed in each row, improving the efficiency of the operation [37].	Field agriculture
3	Full film double ridge mulching machine		This machine is designed for the characteristics of loess soil in the northwest arid region, with a large ridge width of 700 mm, a ridge height of 100-150 mm, a small ridge width of 400 mm, and a ridge height of 150-200 mm. A targeted roller module has been designed, which can operate smoothly and effectively compact the soil on the ridge surface, meeting the operational requirements of full film double ridge furrow mulching in dryland [38].	Field agriculture
4	YTLM-110 ridging laminating machine		The YTLM-110 ridging and laminating machine is a multifunctional facility agricultural equipment that integrates trenching, ridging, leveling, and other functions. It is composed of rotary tillage and ridging shaping devices. The disc plow flips the soil from the middle, the drag plate controls the height of the ridging, and the height adjuster of the compaction roller adjusts the roller force. The machine weighs 310 kg, with a ridge width of 115-120 cm and a ridge height of 10-20 cm. It has the advantages of high homework efficiency and low requirements for supporting power technology [39].	Facility Agriculture
5	IQSM-40/70 ridge laying film fertilizer applicator		The IQSM-40/70 ridging and fertilizing film laying machine has a total weight of about 195 kg and is equipped with a wheeled tractor with a power of 11-18 KW. It can achieve a wide ridge height of 100 mm and a narrow ridge height of 150 mm. It can complete the combined operations of trenching, ridging, shaping, fertilization, spraying, film laying, and soil covering in one go, and is suitable for the mechanized operation of full film double ridge furrowing technology [40].	Field agriculture
6	Hanging rotary tillage ridging and mulching compound machine		This machine can complete mechanized compound operations such as rotary tillage, ridging, drip irrigation belt laying, film laying, and film edge soil compaction through a single operation process. The homework efficiency is 0.17-0.23 hectares per hour, with a ridge height of 23-35 cm and a ridge width of 70-80 cm. The innovative design of this machine is a ridge shaped adjustable ridger, which can adjust the size of the ridge shape infinitely. Can meet the requirements of mechanized operation for facility lifting of watermelon and melon land preparation [41]	Facility Agriculture

3.2 Disc Type Trenching and Ridging Machine

The grooves opened by the disc trencher do not change the original soil structure, the soil is not chaotic, and the soil is in complete contact with the seeds, improving the germination rate (typical disc ridge mulching machines are shown in Table 2). The transmission system of the disc trencher has a complex structure, requires high processing technology, and cannot operate on plots with excessive firewood, which can cause seeds to be exposed to the ground and unable to sprout normally [42, 43]. Its representative models are as follows. The 2MBY-1 inter row film mulching seeder, in conjunction with the forward speed of the power equipment, opens a buried film trench with a depth of 70 cm. Under the pulling effect, the plastic film on both sides is horizontally stretched and pressed into the buried film trench by the pressure film wheel. The diameter of the pressure film is 250 mm. Finally, the covering shovel behind the pressure film wheel is used for backfilling, completing the entire process of trench opening and film mulching. The structure is simple, but there are few experiments. The 1KSH-15 disc trenching machine has a relatively light weight of only 33 kg. It is pulled by a Dongfeng 12 hand-held tractor, and is first cut into soil blocks by six fixed curved blades

that rotate. Then, two fixed side blades are used to trim the trench wall, with a trench depth of 100-200 mm and a trench width of 25 cm. Its compact structure and good road performance make it suitable for small plots of land. However, as early trenching machines did not have fertilization devices, manual fertilization is still required in the future, and the quality of trenching cannot be guaranteed.

Table 2. Typical disc type trenching and ridging equipment in China

Number	Model	Equipment pictures	Characteristics	Applicable scenarios
1	BYMSF-5 corn no tillage deep loosening fertilization seeder		The machine is equipped with a 132.3~161.9kw tractor, using disc type or chisel type ditcher, deep loosening depth of 30~35cm, deep loosening shovel spacing of 60cm, using V-type double rubber wheel suppression roller for soil compaction, working width of 300cm, sowing row spacing of 60cm. It can realize the joint operation of multiple processes such as ditching, ridging, shaping, film laying, fertilization and soil covering at one time.	Field agriculture
2	FORIGO Ridge Forming and Film Covering Machine for Sandy Soil		The machine is suitable for different ridging widths, and is pulled by the tractor three-point suspension device. The disc trencher marks a groove in the ridge body, and the subfilm wheel presses the film edge into the groove to complete the ridging and laminating process [45].	Field agriculture
3	2BMSFZ-2A No till Precision Fertilization and Sowing Machine		The machine is equipped with a power range of 40 ~ 70kw tractor, working row spacing of 400 ~ 650mm, the use of double disc ditcher, the depth can be adjusted in the range of 30 ~ 100mm, equipped with 800L fertilizer box, can reduce the number of fertilizer, fertilization device for the gap single disc, casting single piece, so that the weight of the single increase, to avoid deformation and damage in the operation.	Field agriculture
4	2BFG-16 (230) rotary tillage fertilization seeder		The machine adopts compound operation mode, the fuselage size is 2000×2740×1400mm, the rotary tillage and sowing are completed once, the fertilizer box is compact in structure, the fuselage is short, the corrugated roller is used, and the soil covering effect is good after the operation. The tractor is equipped with 73.5 ~ 110.3kw, the tillage depth is 8 ~ 15cm, the row spacing is 15cm, and the working width is 230cm. Suitable for 14, 16, 18, 20 row planting patterns.	Field agriculture
5	DARL series trenching machine		The machine adopts cutting and throwing separate cutter teeth, can be ditched at one time, suitable for digging large ditches, supporting power of 85 ~ 120 kw, weight of 1130 kg, the maximum ditching depth of up to 135 cm.	Field agriculture

3.3 Furrowing and Ridging Equipment for Share Plow

The plow trenching machine, due to its simple design, fast operation speed, high efficiency, and stable operation, has been widely used in agricultural production in the 1960s. However, due to its bulky structure, high traction resistance, and the large size of residual soil on the edge of the ditch after excavation, which cannot be automatically dispersed, and the need for manual repair of the excavated ditch, its application scope is severely limited. The plow can operate on plots with low soil moisture content, with a tillage depth of up to 18-20cm. However, after plowing, the soil mass is larger, the straw return rate is low, and it cannot operate normally on plots with high soil moisture content. The representative models include the 2LM-F110 tobacco field ridge raising, fertilization, and spraying film covering integrated machine. During operation, it is pulled by a 50 type tractor, which plows the soil to form ridges. The shaping device compacts the ridges to form a trapezoidal tobacco ridge, and the ground wheel film covering device covers the plastic film on the tobacco ridge, which is then

pressed and covered with soil by a compaction roller to complete the film covering operation [46]. Shi Yuliang and others from Qingdao Agricultural University have designed a sweet potato ridge shaping machine. Field experiments have shown that the stability coefficient of the furrow height of the plow type plowing device is 8.53%, the soil compaction of the ridge body is 236kPa, and the fuel consumption of tractor operation is 11.96L/h, which meets the agronomic requirements of sweet potato furrowing and ridge shaping [47].

4. Problems with Ridge Forming and Film Covering Machinery

4.1 Ridge Laminating Machine Design Has Low Universality

The agricultural planting areas in China are widely distributed, with diverse planting modes in the north and south, complex terrain, and a wide variety of crops planted. The ridge shape and spacing required for different regions and crops also vary. The soil environment in the northern region of China is relatively loose, while the soil in the southern region is mostly clay with high moisture content, such as the BP480 ridge mulching machine and the STF-110 series mulching machine. This type of large-scale ridge forming and film covering machine usually requires a heavy driving device, which can cause serious clay and high forward resistance when used in clay environments. Among the various models developed in China, such as the KG-PH9000 potato sowing and mulching machine, this machine has good flexibility and operational performance. It is often used, but its function is relatively single and can only complete specific agricultural operations. It cannot simultaneously complete processes such as ridging, mulching, spreading, pressing, and covering soil.

4.2 Low Integration of Ridge Mulching Machine and Agronomy

The development of core components for ridge forming and laminating machines is not closely related to the development of agricultural technology. The current model development in China is mainly based on universal design, mechanically copying foreign design schemes, without considering the operational requirements under specific conditions. For example, after the operation of the sweet potato ridger, the ridge body is not standardized and does not meet the agronomic requirements well. There are problems such as insufficient ridge height, poor ridge compactness, easy collapse of the ridge body, serious damage to the ridge side, and non-standard ridge spacing.

4.3 Aging Age Structure of Machine Operators

With the development of the social economy, non-agricultural employment opportunities have increased, and more and more young people are unwilling to engage in agricultural production activities. Currently, most of the people who use ridge covering machines are middle-aged and elderly people, with low education levels, low technical literacy, and poor acceptance of new technologies. At present, most of the ridge forming and laminating machines developed in China are still in the pure mechanical control stage, and the automation, integration, and intelligence of the entire equipment are not yet perfect. The operation is more complex, and the machinery is bulky, which is not conducive to the use of farmers.

4.4 Plastic Mulch Causes Environmental Pollution

At present, the traditional PE film is still used for ridge forming and film covering machinery. The coverage area of the 2015 plastic film is 18.33 million hectares, and the input amount is generally between 87.00 and 94.50 kg. ha⁻¹, with a recovery rate of less than 60%. Long term continuous cultivation leads to the accumulation of residual plastic film, hindering the movement of water and fertilizer, deteriorating soil structure, affecting seed germination, damaging agricultural machinery components, and mixing residual film with straw feed, resulting in animal ingestion and death.

5. Suggestions for the Development of Ridge Laminating Machinery

5.1 Improve the Integration of Ridge Raising Equipment and Agronomy

Considering the current situation in China, we can draw on the research and development models of Japan and South Korea. Based on the differences in terrain and soil between the north and south of China, we can follow the principle of easy first, difficult first, and primary then secondary. We can first solve the integration of agricultural machinery and agronomy in large areas such as plains, and then gradually radiate to hilly areas. We can concentrate on improving the width configuration of mulching ridges and open ditches, the water accumulation capacity of ridge mulching technology, and gradually build suitable technical parameters for agricultural mechanization operations. By reasonably determining technical indicators such as homework quality and efficiency, and configuring equipment that meets the requirements of agronomic technology, we can accelerate the meeting of the requirements of different regions and soils in China for ridge forming and film covering machinery

5.2 Improve the Intelligence Level of Ridge Forming and Film Covering Equipment

To improve the mechanization level and efficiency of the ridging and laminating machine, reduce the complexity of the entire operation of the ridging and laminating machine, reduce the difficulty of operation for operators, and thus help reduce the labor intensity of operators. By equipped with sensors, GPS navigation and other equipment, automated operation and intelligent management of mechanical equipment can be achieved. For example, in 2016, Case Company in the United States launched the most representative unmanned tractor, which is equipped with a LiDAR, an in car camera, and eliminates the cab. It can achieve multi machine collaborative path planning and complete various types of work tasks. In January 2022, John Deere announced a mass-produced fully automatic tractor 8R, which combines GPS automatic navigation technology with TruSet automatic leveling technology to achieve unmanned operation of the tractor. In addition, the tractor is equipped with six 360 ° visual cameras, which can detect common obstacles in farmland, plan paths based on the distance of obstacles, and autonomously avoid obstacles. Currently, the tractor has entered the mass production stage.

5.3 Strengthening the Technical Literacy of Farmers

While developing new types of machinery, in order to improve the technical literacy of farmers, it is not only necessary to introduce talents and have professional talents guide the research and development of ridge mulching machines, but also to cultivate farmers to master professional knowledge on their own. Led by the government, we will strengthen cooperation among farmers, cooperatives, and research institutes, organize scientific researchers to go deep into the field, provide precise guidance to farmers on the use of new ridge mulching machines, provide professional training for farmers, and provide technical support and knowledge transmission to farmers, ensuring the production of ridge mulching.

5.4 Suggestions for Treating Residual Film Pollution in Farmland

Whether it is ridge mulching or subsoil mulching, the use of film is related to changes in soil ecology. To solve the problem of farmland residual film pollution caused by ridge mulching machines, one is to do a good job in the recycling of ordinary polyethylene film, and the other is to use degradable film instead of non degradable film. The total amount of film coverage in Europe reaches 470000 to 560000 hectares, but due to the private ownership of land by farmers in Europe, And there is a strict legal system that restricts the use of plastic film, and the spontaneous land protection awareness of farmers makes it almost impossible for plastic film pollution to exist in Europe. However, China's land is owned by the state, and farmers usually use it predatorily during agricultural production. In some areas, plastic film recycling is not even carried out. Therefore, it is necessary to do a good job in the recycling of ordinary plastic film, that is, the recycling rate of newly covered plastic film should

reach over 80% that year, and recover the previous year's plastic film from the soil cultivation layer year by year.

At present, research and development of biodegradable films mainly focus on photodegradable films and biodegradable films. By introducing biodegradable films and biodegradable films into ridge mulching machines, photodegradable films are used to cover the ground and biodegradable films are used to bury the soil. Both the ground and underground parts can be degraded. The degraded film does not affect soil moisture movement, which not only brings economic benefits but also reduces the residual film.

6. Conclusion

At present, the technology and equipment for ridge forming and film covering in foreign countries are relatively mature, and many models have already been applied in the market. The large ridge forming and film covering machinery directly imported from abroad is not suitable for direct application in China, and China's independently developed small ridge forming and film covering machinery is not yet mature. In the future, there is still a long way to go in improving the intelligence level of China's ridge forming and film covering machinery, standardizing domestic agricultural planting models, and improving the overall quality of agricultural practitioners, In response to the existing problems in our country, developing adaptable, low-cost, and efficient ridge forming and film covering machinery, while strengthening the application and promotion policies of new technologies, has profound significance for improving the level of ridge forming and film covering technology in China and reducing the pollution of plastic film residues.

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