Analysis on the Key Problems of Chinese Cotton Full Mechanization Based on System Engineering Theory

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Abstract: Cotton is the main economic crop in China. The whole process of mechanized cotton production is the decisive factor to ensure the stable and healthy development of China's cotton industry. In recent years, the willingness to grow cotton has declined due to labor shortages. Based on the current situation of mechanized production in China, this paper analyzes the problems existing in the six major stages of cotton production and draws the key technical factors (technical problems, production problems, agronomic problems) that restrict the whole process of mechanization in China. Based on the theory of system engineering, combined with the development direction of national agricultural mechanization, it is proposed that the large-scale business model, systematic engineering design, and cotton industry chain integration are the main directions for solving problems, which is of great significance to the advancement of agricultural modernization and the realization of smart agriculture.

1. Introduction
The cotton planting area in China has undergone dramatic changes, and the main producing areas have been transferred from the Yellow River Basin and the Yangtze River Basin to the Xinjiang Cotton Region. Cotton is a labor-intensive cultivation crop, and its planting management is complicated. In recent years, due to the transfer of rural labor to the secondary and tertiary industries, cotton prices have fallen, labor costs are high, cotton planting efficiency is reduced, cotton planting area is decreasing, and planting willingness is not high. How to realize the whole process of mechanization of cotton production, improve the mechanization level of cotton production, greatly save costs and reduce labor, is the future production direction of cotton.

At present, in some countries with developed agricultural technologies in the world, the whole process of cotton production has basically been mechanized, and the per capita management area has reached 1,000 mu. China's Xinjiang Production and Construction Corps has basically realized the full mechanization of cotton production, with a per capita management area of 200 mu. It can be seen that the mechanization of cotton production is not only feasible, but also imperative.

Based on the current status of mechanized production of cotton, this paper analyzes the regional advantages and policy analysis of each cotton area, analyzes the six major aspects of cotton production in China, and analyzes the key issues of mechanized production of cotton through system engineering theory, through the combination of agricultural machinery and agronomy. The way to propose a large-scale business model, systematic engineering design, cotton industrial chain integration, etc. is to solve the problem direction, in order to provide theoretical guidance for the healthy development of China's cotton, and provide a guarantee for the sustainable development of the cotton industry.
2. Analysis of the status quo and problems of key links in mechanized production of cotton
At this stage, In addition to the Xinjiang cotton area, the production methods of other cotton areas in China are relatively backward. Low level of mechanization, Small scale of operation, Low labor productivity and high production costs. In the whole process of cotton production, only part of the mechanical operation of land cultivation, planting, plant protection and cotton picking, Mechanized operations have not yet been achieved in the cotton picking process, which has a large labor force, still in the exploratory stage.

2.1. Ploughing and finishing
Mechanized land preparation technology refers to the improvement of the soil layer structure through the interaction of disc harrows, laser graders, subsoilers, so as to construct a good soil environment for cotton sowing. The mechanization of the land preparation is the beginning of the whole mechanization of cotton. The quality of the land preparation directly affects the seeding effect. At present, the cotton field cultivation and land preparation technology has basically achieved a mechanization rate of 98% for mechanized operations.

2.2. Sowing
Cotton sowing technology has experienced semi-precision sowing to precision sowing, The precision seeders currently being promoted are mainly Development of Xinjiang Academy of Agricultural Reclamation Xinjiang Keshen Agricultural Equipment Technology Development Corporation for as 2BMJQ-1/4 and 2BMJQ-3/18, Air suction cotton precision filming planter. Capable of on-film, sub-film precision seeding, Technology has reached international leadership.

In order to improve the recovery rate of the 3 rows of cotton pickers, the Binzhou Agricultural Mechanization Science Research Institute and the Nanjing Agricultural Mechanization Research Institute of the Ministry of Agriculture jointly developed the 2BMJ-3A intelligent precision seed drill based on machine cotton picking. Sowing, using the principle of hole type to achieve seeding, to achieve fine broading. At present, the mechanization rate of cotton sowing in China is 98%, but the seeding mode on the membrane is mainly concentrated in Xinjiang, Binzhou and Dongying.

2.3. Mid-term management
The management of cotton cultivating field includes cultivating and topdressing, plant protection, irrigation and pruning.

2.3.1. spraying
In recent years, China's agricultural plant protection mechanization has developed rapidly, and a variety of backpack-type and suspended sprayers have been developed. Especially suitable for the middle and late management of crops, the high-gap sprayer has developed rapidly, and a number of sprayers suitable for field operations have emerged. The representative and representative Shandong Institute of Agricultural Machinery Science 3WPZ-650 intelligent backpack spray Machine, Dongfanghong-3WPZ2500 high ground clearance self-propelled plant protection machinery, Yatai 3WZC-1300A high ground clearance self-propelled spray bar sprayer, 3WZG-650 self-propelled high ground gap spray bar sprayer and other new plant protection machinery in China Has been widely used.

2.3.2. cultivating soil
Cultivating soil is one of the key technologies for mid-term management of cotton, Can function as loose soil, soil, and ridge. It is conducive to promoting cotton seedlings to be robust. At present, the cultivating and fertilizing machinery used in the market is mostly used with walking tractors. Soil working parts mainly have spiral, disc, spring gear, cymbal, coulter, etc. More representative are the cotton cultivator and soil cultivator produced by More representative Qufu City Shengtong Machinery Equipment company Limited, Jining Zhanhua Machinery Manufacturing company Limited, Guangxi
2.3.3. topping
Cotton topping is the key link for increasing cotton production and income. Timely topping can eliminate the top advantage of cotton plants and promote boll opening to achieve early maturity, high yield and stable yield. At present, the topping operation of cotton is divided into manual topping and chemical control topping. The labor intensity of artificial topping is large, the operation efficiency is low, and the farming time is delayed. The chemical control topping technology needs to spray the liquid several times, which is affected by unforeseen factors such as external conditions. Larger and polluting the environment.

The domestic cotton machinery topping technology has experienced the development process from the whole machine profiling, to the local contouring to the single-line profiling. The more representative research is mainly concentrated in Xinjiang 3MD-12 cotton topping machine and 3WDZ-6 self-propelled. Cotton topping machine (Hu Bin, 2000; Zhou Haiyan, 2000; Zhang Xiaohui, 2010), 3MDZ-4 self-propelled cotton topping spray combined working machine in the Yellow River Delta cotton area (Peng Qiangji, 2015, 2019), but due to Affected by the complex working environment of cotton fields, most of the topping machinery and equipment are currently in the experimental stage.

2.4. Mechanical harvesting
The artificially harvested cotton has an average daily working efficiency of 60 kilograms of seed cotton. This requires a lot of manpower, material resources and financial resources to complete the harvesting operation and brings many social and economic problems. Manual harvesting of cotton has become an obstacle to the mechanized production of cotton.

Mechanization of cotton harvesting is a systematic project involving cotton varieties, agronomic cultivation measures, field production management, residual film recycling, chemical defoliation ripening, mechanical harvesting, cotton cleaning and processing, lint quality standards, etc., mechanical picking In terms of labor liberation, total factor productivity improvement, and economic effects, the advantages are obvious. Under the background of China's development of high-quality and low-cost cotton picking machines, the harvesting link is still the key to restricting the mechanized production of Chinese cotton.

2.5. Cotton rod harvesting
Cotton tampon is the main by-product of cotton, and the recycling of cotton stalks will generate huge economic benefits. At present, the cotton swab has three types of harvesting machines: cutting type, root cutting type, and lifting type, and the cotton rod harvesting has been basically solved. More representative are the 4MG-275 self-propelled cotton stalk combine harvester developed by China Agricultural Machinery Institute, Tianli brand 4MC-2 type cotton boring machine produced by Hebei Qiu County Tianli Machinery Co., Ltd., Binzhou Jingguo Agricultural Machinery The cotton rod crushing baler and other machinery developed by the Manufacturing Co., Ltd. The cotton stalk collection and initial processing are completed mainly by mechanized techniques of cotton stalk harvesting, mashing and bundling.

2.6. Cotton film residual film recycling
The mulching cultivation technology has the functions of warming, protecting, protecting fertilizer, inhibiting weed growth, reducing crop diseases and increasing cotton yield. However, because the molecular structure of the waste residual film is very stable, it has the property of being non-perishable and difficult to decompose, and it can remain in the soil for a long time, which has a very negative impact on agricultural production, soil and environment. China's cotton agricultural film use is more than 96%, and the residual film thickness is between 0.004 and 0.008 mm. After one working season, the film strength and toughness are greatly reduced, and it cannot be retracted. It can only be recycled
by shovel, shovel, shovel, etc. The residual film recovery machine has a low degree of intelligence, and the residual film is easily transported after the recovery of the residual film. Developed the intelligent control system for picking up parts, and developed an intelligent residual film picking and packing combined working machine that integrates residual film picking, cleaning, stripping and packing. Improving the quality and efficiency of residual film recycling is the direction of residual film recycling.

3. Analysis of key problems

3.1. Cotton topping problem
The 3MDZ-4 self-propelled cotton topping spray combined working machine designed for China's cotton growth characteristics (Peng Qiangji, 2015, 2019), but due to the complex working environment of cotton fields, the current topping machinery and equipment stayed in the experimental stage. Integrated information acquisition, electro-hydraulic integration, intelligent control and other advanced technologies, innovative development of cotton height detection devices, response to the topping device and other components and key components combined with the touch screen control system is the key to this link.

3.2. Cotton mechanized harvesting problem
(1) The operation mode and planting scale are small, and it does not meet the requirements of machine mining.

At present, the main business model of cotton in the Yellow River Delta includes household contract responsibility mode and small cooperative mode, of which the family planting mode accounts for 50%, the small cooperative mode is less than 40%, and the small cooperative mode is mainly planted with an area of about 20 mu. The minimum size of mechanical picking is 100 mu (the machine can recover more than 100 mu to ensure the income is higher than the manual picking mode). The planting scale is small, the cotton planting is not concentrated, the planting varieties are not uniform, and there are no planting standards.

(2) The variety is disorderly and does not meet the mechanical mining standards.

Most of China's cotton planting characteristics are low density, high plant, long and thick branches, and the spacing between rows is not uniform. It is not suitable for machine mining, it is difficult to achieve full mechanization, and it is improved from variety. The close cooperation between agronomy and agricultural machinery is the only way to solve the mechanization of cotton production in the region.

(3) The planting mode is not uniform and does not meet the agronomic standards.

The basic methods of cotton harvesting are 68cm+8cm and 66cm+10cm. The 68cm+8cm belt planting method proposed to adapt to the harvesting structure of the cotton picker has the characteristics of allowing the cotton picker to perform one-time harvesting operation, which is beneficial to the efficiency of the cotton picker, the small loss of the cotton drop, and the small loss of output.

70% of China's cotton planting is mainly based on family planting. In addition to the cotton planting pattern in Xinjiang, it is used for intercropping, interplanting (garlic cotton, wheat-cotton, cotton and potato intercropping), crop rotation (cotton and forage rye crop rotation), etc. Mainly, farmers simply pursue short-term economic benefits, lacking the motives and mechanisms for long-term large-scale operation and organizational management. It is difficult to promote the planting mode of machine-cut cotton in the Yellow River Delta cotton area and the Yangtze River basin.

4. Key Problem Solution Analysis

4.1. Unified variety, coupling machine seeding requirements
Unify cotton varieties and choose cotton varieties suitable for mechanized harvesting. Fruit hardness
meets mechanical harvesting requirements. Choose a variety that is easy to separate between cotton bolls and cotton coats, avoiding cotton bolls, reduce the floor cotton and the hanging cotton, thereby improving the mechanized cotton picking rate. Cotton sowing, fixed line spacing, can’t change the plant spacing, do the fine cotton planting.

4.2. Field management standardization, goal-oriented management
(1) The tone. Cotton growth period cotton on time, according to quantitative adjustment, to ensure the height of the fruit section and the length of each section of the cotton plant, cotton plant height and cotton picker adaptation, improve the recovery rate.

(2) Spraying defoliating agent and picking time and order are strictly in accordance with the standard. The choice of drugs, the amount of drug, and the time of spraying ensure the quality of leaves and the yield of cotton to reduce the rate of harvest.

(3) The combination of agricultural machinery and agronomy is designed to meet the unsupported cutting device at the top of the cotton, separate the detection device from the topping device, separate the lifting power from the cutting power, and realize a series of automatic operation functions such as one-button control and real-time operation status display to ensure Intelligent self-propelled cotton precision topping plant protection combined with the whole machine intelligent control, saving time and effort, efficient and accurate.

4.3. According to the nature of cotton, rationally arrange circulation links
(1) Provide space for picking and loading and unloading space for machine picking
When mechanized harvesting, leave enough space for the cotton picker to avoid crushing the cotton plant and losing cotton to reduce losses. The picking and unloading machine needs to be spacious and clean. At present, there is no standard loading and unloading site in the Yellow River Delta cotton area. If a large area of machine cotton is used, cotton and fashion unloading cannot be guaranteed, and the loading and unloading delay on the day will affect the next day's cotton picking. The problem of the size and height of the cotton carriages is a potential problem in the whole process of mechanized production.

(2) Enhance fire safety awareness
Cotton is a flammable item, and there are high fire safety hazards in picking, loading, unloading and transportation. The safety awareness of picking drivers, loading and unloading personnel, and transporting drivers will affect the safety of cotton.

4.4. System Engineering Design
Mechanization of cotton harvesting is a systematic project involving cotton varieties, agronomic cultivation measures, field production management, residual film recycling, chemical defoliation ripening, mechanical harvesting, cotton cleaning and processing, lint quality standards, etc., according to domestic The requirements of mechanized technical equipment for cotton harvesting combined with the status quo of cotton production in China, especially the Corps, have comprehensively improved and optimized the traditional mechanization process of cotton planting from the height of system engineering, and have promoted the application of cotton harvesting mechanization technology in production.

The five major links of cotton planting in China are not systematic and still develop independently. The independent mechanization rates of each link are 95% of cultivated land, 98% of sowing, 60% of intermediate management, and 5% of harvest. The average mechanization rate of each link is not high, and the average level is not high. The efficient way of mechanization rate of cotton is to implement cotton system engineering design and production on the basis of intensive scale operation, including cotton varieties, agronomic cultivation, field production management, residual film recycling, topping, mechanical harvesting, cotton cleaning and processing, and lint quality. Standards and other links are unified into the standard production of cotton, and the mechanization of cotton is accelerated.
4.5. Open the cotton industry chain and information production.
System engineering design requires the high integration of the “production, supply and marketing” industrial chain in cotton production, and the integration of the three systems. Cotton harvest is not an independent link. It is a high degree of unification and coordination in pre-production, mid-production, post-production, circulation and processing. Every link that does not meet the standard will become the key to restricting the whole process of cotton mechanization. Therefore, the cotton industry chain will be opened and production information will be opened. It is an important preliminary work.

5. Conclusions and prospects
The whole process of mechanized cotton production is a systematic project. In order to achieve the highest cotton mechanization rate effect, Cotton varieties, agronomic cultivation measures, field production management, residual film recycling, chemical defoliation ripening, mechanical harvesting, cotton cleaning and processing, and lint quality standards must be highly integrated.

The level of mechanization rate in China's cotton production is uneven in the above-mentioned links. The topping and mechanical picking are the key issues in the process of agricultural modernization. From the business model, systematic engineering design and production, and the opening of the cotton industry chain are the main directions for solving the problem. It is of great significance to the advancement of agricultural modernization and the realization of smart agriculture.

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References
[1] Peng Qiangji, Kang Jianming, Song Yumin, He Qinghai. (2019) Design of 3MDZ-4 self-propelled cotton topping spray combined working machine. Transactions of the Chinese Society of Agricultural Engineering, 35(14): 30-38.
[2] Wang Qiaohua, Wen Fufu, Zhang Hongzhou, Yuan Cheng, Li Li. (2019) Classification of residual film in machine-made cotton by electrostatic adsorption method[J]. Transactions of the Chinese Society of Agricultural Machinery, 50(06): 140-147.
[3] Wu Jianshe, Chen Xuegeng. (2015) The current situation and countermeasures of the development of cotton production mechanization in Xinjiang Corps[J]. Transactions of the Chinese Society of Agricultural Engineering, 31(18): 5-10.
[4] Noah. (2014) Committed to the mechanization of cotton planting in China. Academician of Chinese Academy of Engineering Chen Xuegeng, Agricultural Machinery Specialist. Hubei Agricultural Sciences, 53(15): 3464.
[5] Liu Beihua, Lei Wei, Zhan Ling, Song Yang, Yang Zhao. (2014) The whole process of mechanization: the inevitable choice for the development of cotton industry in Xinjiang—Taking Hugebuhu Village, Dalet Town, Bole City, Xinjiang as an example. China Agricultural Resources and Regional Planning, 35 (01): 8-11+43.
[6] Chen Xuegeng, Lu Yongtao. (2010) Experiment on the Seeding Performance of Air-absorbent Drum-type Cotton Precision Hole Booster. Transactions of the Chinese Society of Agricultural Machinery, 41(08): 35-38.
[7] Wu Fuan. (1993) Shandong Cotton Science and Technology System Engineering. China Cotton, (06): 43.