Regarding the Creation of a Vertical Spindle Cotton Picking Machine for Harvesting Cotton in a Single Pass

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Abstract: In Uzbekistan, the climatic conditions do not allow cotton to open up more than 80-90%, so cotton is harvested when it is 50-60% open, even when the field yield is 25-30 c/ha. This is done using horizontal spindle machines (HSM). As a result, harvesting costs increase significantly and the quality of the harvested cotton fiber deteriorates. To address this issue, it is proposed to install a six-drum (triple-processing) harvesting apparatus on the MKh-1.8 model machine at TSTU. This setup allows for harvesting cotton when the bolls are 85-90% open and ensures that 93-94% of the cotton yield can be collected. In this process, the cotton left on the ground does not exceed 3%, and the contamination of the cotton in the hopper does not exceed 8%.

1 INTRODUCTION

It is well known that cotton raw material production is a labor-intensive process. For raw material production, in the autumn, the fields are plowed to a depth of 35-40 cm with a two-layer plow, and the upper layer is leveled. Considering that 70% of the arable land in our republic is saline, in the autumn or early spring, a special device (chelp) is prepared to wash away the salinity of the land, and these areas are irrigated 2-4 times to flush out the salt.

2 MATERIALS AND METHODS

After the salinity has been washed out, the fields are leveled 4-6 days later, and then they are loosened to a depth of 20-25 cm using ChKU-4A chisel-cultivators. If necessary, based on agronomic requirements, the fields are fertilized in strips to a depth of 15-20 cm with fertilizers such as nitrogen, phosphorus, potassium, and organic or other microelement fertilizers.

Depending on the climatic conditions and the specific characteristics of each zone, cotton seeds are sown into the soil using tractor-seeder units. After the cotton seedlings, which emerge from the sown seeds, develop two to three leaves, the furrows are prepared, and the first irrigation is applied to the cotton rows. Subsequently, the cotton rows undergo several mechanized treatments, including soil loosening, fertilization, furrow preparation, irrigation, and weeding, as well as pest control and other necessary operations.

After 2-3 of the cotton bolls have opened, defoliation of the cotton fields is carried out. Currently, after the cotton has ripened and 50-50% of the bolls have opened, manual harvesting of the cotton starts in approximately 70% of the fields. Before mechanical cotton harvesters collect the raw cotton, the cotton plants undergo defoliation, meaning that the green leaves are chemically treated to be removed at a rate of 50-70%. The leaf drop occurs within 3 days.

Until the year 2000, according to cotton cultivation technology (GOST 22587-91) (Sablikov, 1985; Shpolyanskiy, 1985; Matchanov, 2010; Rizaev, 2017), the first machine harvest was carried out after 75-80% of the cotton leaves had fallen due to defoliation, and when 55-60% or more of the bolls had opened.

The second machine harvest was conducted 10-15 days after the first one, when an additional 20-25% of

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the bolls had ripened and opened. In some regions, a third machine harvest was also performed. After this, the leftover cotton on the ground and on the cotton stalks was collected by harvesters. Due to the fact that this two-stage technology led to longer harvesting periods and increased harvesting costs, it is no longer commonly used by modern farming operations.

Currently, in farming operations, machine harvesting is conducted when 80-90% of the cotton bolls are open. An analysis of the technological process and agronomic indicators of the MX-1.8 vertical spindle cotton harvesting machines (VSH PTM) reveals that the harvesting efficiency does not exceed 80-85%. Additionally, cotton loss on the ground is about 4-5%, and contamination of the cotton in the bunker reaches 10-11%. These agronomic indicators result in a cotton price that does not meet the satisfaction of farmers and reduces the effectiveness of the MX-1.8 vertical spindle machines. Consequently, farmers use the MX-1.8 machines only in certain situations or when no better alternatives are available (GOST 22587-91), (Sablikov, 1985; Shpolyanskiy, 1985; Matchanov, 2010; Rizaev, 2017; Matchanov, 2018; Matchanov, 2023; Matchanov, 2024).

Due to the increasing cultivation of fast-ripening and high-yielding cotton varieties in Uzbekistan, horizontal spindle cotton harvesting machines (from the USA and China) with high efficiency and productivity have been widely used in the country's farming operations and cotton clusters. These machines are employed in fields where cotton bolls are 80-90% or more open. When harvesting cotton with these machines, the harvesting efficiency indicators can reach up to 90-95% (Matchanov, 2010; Matchanov, 2018; Matchanov, 2023; Matchanov, 2024).

Because of climatic conditions and weather variations in Uzbekistan, cotton bolls often do not open 80-90% of the time every year. Consequently, even when cotton bolls are 50-60% open and the yield in the field is 25-30 centners per hectare, harvesting with horizontal spindle machines (HSM) has proven to be ineffective based on current practical experience. This is because, in such cases, harvesting costs increase sharply and the quality of the harvested cotton deteriorates. Specifically, HSMs collect cotton with bolls that are not fully open and ripe. Additionally, the cost of cotton harvested by HSMs is significantly higher compared to vertical spindle machines (VSM), making farmers uninterested in using these machines.

3 RESULTS AND DISCUSSION

In the 1960s and 1970s, the high-efficiency vertical spindle cotton harvesting machines (VSH) were developed through scientific research and experimental design work carried out by the staff of the Institute of Mechanics and Seismic Stability of Structures of the Academy of Sciences of Uzbekistan in collaboration with the "Toshselmash" factory engineers. The ANTX-1.2 and ANTX-1.8 models of VSH machines created during this period continue to fully meet the demands of modern farming operations, as evidenced by practical experience. Therefore, recognizing the scientific significance of these developments is considered an important task (Matchanov, 2010; Rizaev, 2017).

Between 1975 and 1983, based on the ANTX-1.2 and ANTX-1.8 models of vertical spindle cotton harvesting machines (VSH), a new model, the 3XVN-1.8 "Dostlik," was developed in collaboration with the staff of the "Toshselmash" factory and the Tashkent Institute of Irrigation and Melioration (TIQHM). State tests confirmed that this machine could achieve up to 93-94% harvesting efficiency for cotton bolls that were 85-90% open in a single pass.

The machine featured a cotton harvesting apparatus with a three-row spindle drum (6 spindles in a single row) and an automatic adjustment mechanism for the working gap. It was produced on an industrial scale at the "Toshselmash" factory and passed state testing. After addressing some constructive flaws identified during the state trials, the machine was recommended for implementation in agricultural practice. However, the main drawback noted in the test report was that the contamination level of the cotton in the machine's bunker was 2-3% higher compared to serially produced VSH models (Matchanov, 2010; Rizaev, 2017; Matchanov, 2018; Karimov et al., 2019; Matchanov, 2023; Matchanov, 2024).

At TSTU scientific researchs was conducted to address the shortcomings of the previously mentioned cotton harvesting apparatus and to improve its design. The following recommendations were developed based on the results of this research (Karimov et al., 2019; Khajiev et al., 2024):

1. To achieve a picking efficiency of 93-94%, it is necessary to install drums with a diameter of 216 mm (along the spindle rotation axis) on the new picking apparatus, along with 10 spindles (with a spindle spacing of 67.8 mm on the drum), and to place pairs of drums that provide triple processing of the cotton (6 drums in a single row of the picking apparatus).

2. To increase the energy efficiency of the machine, reduce the coefficient of spindle drum slippage to between 1.3 and 1.35.

3. Install a simplified mechanism on the VSH PTM picking apparatus that automatically adjusts the working tension based on the field's agroenvironment.

4. To ensure even loading of each pair of drums and reduce contamination of the cotton in the hopper, install the drums on the picking apparatus with adjustable height (see Figure 1, positions 2, 4, and 6 as shown).

5. Install spiral-shaped cotton separators, as proposed by Academician Sadriddinov A.S., on the picking apparatus.

These recommendations aim to enhance the performance, efficiency, and quality of the cotton harvesting process.

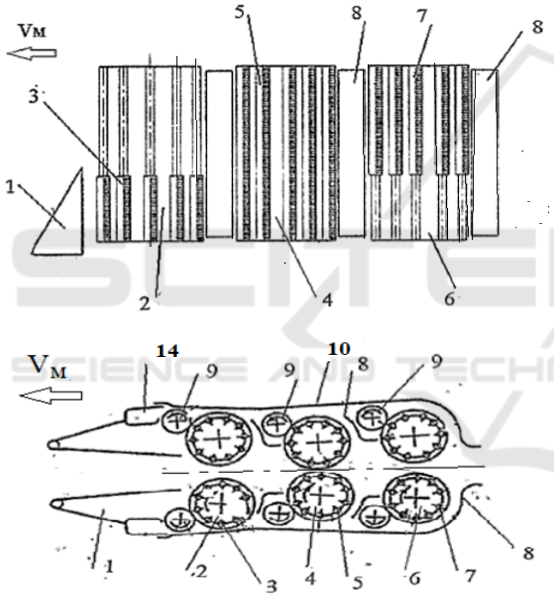

Figure 1: Diagram of the cotton picking apparatus designed to harvest 93-94% of cotton with 85-90% of the bolls opened in a single pass:1 - Elevation frame; 2 - First pair of drums (working height from the ground: 220 mm); 3 - Spindles (working height from the ground: 220 mm); 4 - Second pair of drums (working height: 615 mm); 5 - Spindles (working height: 615 mm); 6 - Third pair of drums (working height from the top: 400 mm); 7 - Spindles (working height from the top: 400 mm); 8 - Shield; 9 - Spiral-shaped cotton separator; 10 - Shield; 11 - Collection chamber.

4 CONCLUSIONS

1. At Tashkent state technikal university, a vertical spindle cotton harvesting machine (VSH) with three pairs of drums (6 drums in a single row) was designed, which can achieve up to 93-94% harvesting efficiency when 85-90% of the cotton bolls are open. The main parameters and design of this harvesting apparatus were developed based on these capabilities.
2. For use in Uzbekistan's farming operations, it is recommended to install a vertical spindle harvesting apparatus with three pairs of drums (6 drums in a single row) on the MX-1.8 machine. This apparatus provides triple processing of open cotton bolls.
3. Currently, the complex and expensive horizontal spindle cotton harvesting machines produced abroad (in the USA and China), which significantly increase the cost of cotton harvesting and severely degrade the quality of the harvested cotton in our natural climate and weather conditions, should be replaced. It is recommended to switch to the MX-1.8 VSH with the triple-processing drum apparatus (6 drums in a single row).
4. Implementing the recommended MX-1.8 VSH with a three-pair drum harvesting apparatus in farming practices will improve the economic efficiency of the farms and enhance the effectiveness of the VSH machines.

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