Combined cotton picker with interchangeable devices

R Matchanov¹, A Rizayev², K Astanakulov³, A Tolibaev⁴ and N Karimov⁵

¹ "Agrixim" JV, Sultanali Mashkhati str. 210, Tashkent city, Uzbekistan
² Institute of Mechanics and Seismic Stability of Structures after M.T. Uzarbayev, Akademgorodok, Tashkent, Uzbekistan
³ Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Tashkent, Uzbekistan
⁴ Center for Certification and Testing of Agricultural Machinery and Technologies, Tashkent region, Yangiyul district, st. Yoshlik 5, Uzbekistan
⁵ "Uzagrotekhsanoatholding" JSC, Buyuk Ipak Yuli 434 str., Tashkent, Uzbekistan

E-mail: raf1942@mail.ru

Abstract. Weather conditions in the risky cotton growing area largely determine readiness of the agricultural background of the cotton field for machine harvesting of cotton. A combined cotton picker with replaceable horizontal spindle and vertical spindle devices was invented. At full (85-90%) opening of cotton bolls, an option of a cotton picker with horizontal spindle is applied, and at incomplete (55-60%) opening – an option with vertical spindle devices is applied. Field trials of a cotton picker with removable devices were carried out. The estimated parameters were completeness of cotton harvest, residue on bushes, losses to the ground, debris and moisture of harvested cotton. Use of a combined cotton picker allows to harvest cotton selectively at full and incomplete opening cotton bolls. Productivity and cotton-picking quality has increased.

1. Introduction

Based on the real conditions of cotton cultivation in cotton-growing countries of the world, there are two technologies for picking cotton: horizontal spindle and vertical spindle. At horizontal spindle, picking of cotton is at full (85-90%) opening of cotton bolls, harvested by the one machine pass. At vertical spindle, picking of cotton with incomplete opening of bolls crop that are harvested in two passes with extended harvest periods. The first pass of a machine is at 55-60% boll opening, and a second one in 10-15 days after disclosure of remaining boxes. Cotton growing in Central Asia occurs in the risky agricultural zone area. The weather conditions of the particular zone area determines the readiness of the agricultural background of a cotton field for machine harvesting utility. Disclosure percentage of bolls harvested by cotton machine over the year ranges from 55-95%. It is economically inexpedient to have two types of cotton pickers at the farm.

A number of works are devoted to development and improvement of cotton pickers’ machines. O.S. Dzhabbar [1], A.D. Glushchenko [2], A.A. Rizayev [3,4,5], R.I. Spevakov [6], A.D. Abdazimov [7] investigated technological processes of cotton picking by vertically spindle and horizontally spindle machines. The works of A.V. Butyrin [8], D.F. Khamrayev et al. [9], R.I. Spevakov [10], N.T. Lityucheko [11], V.A. Ivanov [12], N.A. Kulametov [13], A.D. Glushchenko and others [14], I.Kh. Igamberdiyev and others [15], O.V. Novitskiy [16], R.D. Matchanov and others [17] are devoted to improving quality of cotton picking by vertical-spindle cotton pickers. These studies are aimed at improving the known...
horizontal-spindle and vertical-spindle cotton-picking technologies. M. Tashboltayev [18], V.N. Gorn, I.M. Yusupov [19], M.Andapulatov [20], A. Numanov [21], Sh.D.Dadazhanov [22], K.B. Karimov [23], U.K. Aytpenov [24] proposed a number of solutions to improve vertical-spindle devices.

Despite the extensive research and proposals to enhance the vertical spindle devices, the analysis of literature sources shows that until now, there lacks information addressing the issue of innovating a cotton picker machines that can selectively pick cotton using a replaceable harvesting devices. Cotton picking remains a problem with incomplete (55-60%) and full (85-90%) opening of cotton bolls with a single technical tool at minimal costs and required quality of raw cotton. The purpose of this work is to develop technology and inventing a cotton picker for selective picking of cotton with different degrees of opening of cotton bolls. To do this, it is necessary to develop a cotton picker with interchangeable units, which would harvest raw cotton selectively at a boll opening level of 55-60% and 85-90%. To establish effectiveness of development a field test of a new cotton picker is required.

2. Research method

To develop a combined cotton picker, a two-row, vertical-spindle, semi-mounted MX-1.8 cotton picker, produced by Tashkent Agricultural Machinery Plant, was used as a basis. For quick change of apparatus, the main systems of a cotton picker (mechanical, pneumatic, hydraulic) have been unified. At 85-90%, boll opening horizontal-spindle devices were hung on the common frame (chassis), and at 55-60% of boll opening vertical-spindle devices were hung.

Field tests were carried out in the Center for Testing Techniques and Technologies (CTTT) in 2019. The purpose of tests was to evaluate machine performance with horizontal spindle and vertical spindle devices at full (>90 percentage) cotton boll opening. Cotton harvesting with a vertical-spindle apparatus with full opening of cotton bolls was carried out using fractional harvesting technology (cotton picking in one pass of a machine, along with this, second and subsequent passes of a machine are carried out with a shift of the devices by one row to the side of a processed field [17]).

Figure 1. Cotton picking machine MX-1.8GV with horizontal spindle devices.

Performance indicators of the machine were compared with the requirements of the organization standard Ts 25272604-017: 2015, registered in the state register on 21.08.2015 by Uzbek Agency for Standardization, Metrology and Certification as “Cotton picking machine MX-1.8. Technical terms”. Evaluation of efficiency of a combined cotton picker was carried out during field trials. The following parameters were taken as estimated parameters: completeness of cotton picking, residues on bushes, and losses on the ground, weediness and moisture content of raw cotton in the bunker of a cotton picker.
The cotton picker was aggregated with an LS wheeled tractor with an 80 hp power. Cotton was picked at speeds: 3.24; 3.96 and 5.4 km/h.

3. Results and discussion
Analysis of long-term observations of timing of sowing and harvesting of cotton showed their significant variability. Figure 2 shows changes in pre-sowing conditions (precipitation and rainy days) over the years. Figure 3 shows the state of the agricultural background (percentage of boll opening before machine picking of cotton). For example, in 1990 there were 15 rainy days and cotton boll opening was 65%. In 1999 there were 8 rainy days and the boll opening rate reached over 90%. Consequently, in 1990, the crop had to be harvested in two passes with a vertical-spindle cotton picker, and in 1999 - with a horizontal-spindle cotton picker, in one pass.

![Figure 2. Total precipitation within the period from March 25 till April 25 (*number of rainy days on an annual basis).](image)

![Figure 3. Degree of opening of cotton bolls before cotton harvesting.](image)

The observations were carried out in the area of the CITT location (Center for Testing Techniques and Technologies, Tashkent region). In general, if one analyzes the degree of opening of cotton bolls by years for 37 years (1980-2016), then taking into account the percentage of opening bolls within the range of 55-68% it would take 16 years. In the remaining 21 years, the percentage of boll opening ranged from 85-90%. Moreover, in recent years, the degree of boll opening has been growing. Figure 4 shows performance of the machine with horizontal spindle devices. In figure 5 performance indicators of the machine with vertical-spindle devices with fractional cotton picking are given.
Completeness of cotton picking by the machine with horizontal spindle devices at the speed of 4.0 km/h was 91.84%, and at the speed of 5.6 km/h - 87.62%. When working with vertical spindle devices (figure 5) completeness of cotton picking decreases as the working gap of the apparatus increases at all speeds of the machine (3.3; 4.3 and 5.6 km/h). Increasing the width of a working slot for vertical spindle cotton pickers allows to reduce the energy intensity of a cotton picking process and its contamination. In addition, when entering a working slot of the apparatus, the bushes are less suppressed, which can increase a working speed of the machine. Therefore, it is important to select the required speed of the machine and width of a working slot of the apparatus for fractional cotton picking. So, in case of fractional cotton picking (figure 5) at the speed of 4.3 km/h and a working gap of 36-32 mm, harvesting completeness was 95.55%, and at the speed of 5.6 km/h it slightly decreased and amounted to 95.15%.
With reference to completeness of cotton picking, a combined cotton picker with horizontal-spindle and vertical-spindle devices for one pass at fractional picking are on the same level. However, performance of a horizontal spindle machine is clearly higher (more than twice). In the future, it is necessary to look for ways to improve the quality of harvest and productivity of a combined cotton picker of vertical-spindle design in low-yielding fields. Here we compared the work of some options of a combined cotton picker at full opening of cotton bolls (>90%). However, the version of a cotton picker of vertical spindle design is designed to work in unfavorable weather conditions, when it is not possible to achieve full opening of cotton bolls.

4. Conclusion
In the zone of risky farming, weather conditions significantly affect readiness of the agricultural background of the cotton field for machine harvesting of cotton. Until now, the problem of machine harvesting of cotton has not been solved selectively at full (85-90%) and incomplete (55-60%) opening of cotton bolls using a single technical means. A developed combined cotton picker with replaceable horizontal-spindle and vertical-spindle devices allows to harvest cotton selectively at full and incomplete opening of cotton bolls. A combined cotton picker with interchangeable devices provides an increase in productivity and quality of cotton picking at various degrees of readiness of the agricultural background of the cotton field for machine harvesting.

References
[1] Dzhabbar O S 1977 Cotton Picking Device Theory (“Fan”, Tashkent)
[2] Glushchenko A D, Matchanov R D, Rizayev A A, Tashboltayev M T, Khudaykuliyev R R 2004 Modelling of Dynamic Processes in Horizontal-Spindle Harvesting Devices. (“Fan”, Tashkent)
[3] Rizayev A A 2017 Study and Development of of working bodies for a cotton picker with high efficiency ("Fan", Tashkent)
[4] Rizaev A, Yuldashev A, Kuldoshev D, Abdillaev T and Ashurov N 2020 IOP Conf. Series: Materials Science and Engineering 883 012157. doi:10.1088/1757-899X/883/1/012157
[5] Rizaev A, Yuldashev A, Kuldoshev D and Ashurov N 2020 IOP Conf. Series: Materials Science and Engineering 883 012166. doi:10.1088/1757-899X/883/1/012166
[6] Spevakov R I 2015 Mechanization of processes of harvesting fine-staple raw cotton. "Fan va Tekhnologiya", (Tashkent)
[7] Abdazimov A D 2007 Research Basis for Increasing Efficiency of Cotton Pickers by controlling parameters of collection process and a harvesting device. (Tashkent)
[8] Butyrin A V 1972 AC No.347027 Two-phase Cotton Harvesting Method B.I. 24
[9] Khamrayevet D F et al. 1988 AC No.1435191. Method of Harvesting of Raw Cotton. B.I. 41
[10] Spevakov R I et al 1999 Patent of RUz No.5615. Method of Harvesting of Raw Cotton Yield. Sci Bull. 2
[11] Lityuchiy N T 1974 AC No.414974. Method of Pre-Harvesting Treatment of Cotton Bushes. B.I. 6
[12] Ivanov V A 1980 AC No.710539. Method of Harvesting of Raw Cotton. B.I. 3
[13] Kulametov N A et al 1980 AC No.718046. Method of Cotton Harvesting and Cotton Picker Used for it. B.I. 8
[14] Glushchenko A D et al 1990 AC No.1504221. Method of Preparation of Cotton Fields and Machine Harvesting of Raw Cotton. B.I. 41
[15] Igamberdiyev I Kh et al 1991 AC No.1674728. Method of Machine Cotton Harvesting. B.I. 33 1991.
[16] Novitskiy O V 1993 AC No.1834632. Method of Raw Cotton Harvesting. B.I. 30
[17] Matchanov R D et al 2019 Patent of RUz No.IAP 05971. Sci Bull. 10.
[18] Tashboltayev M T 1988 J Mech. of Cotton Growing 1 12-3
[19] Gorn V N and Yusupov I M 1988 J Mech. of Cotton Growing 1 12-3
[20] Andapulatov M 1987 Justification of parameters of the spindles of the rear pairs of a harvesting
device of a vertical-spindle cotton harvesting machine (Tashkent) p 19
[21] Numanov A 1970 Research and substantiation of an optimal ratio between a lead factor and number of spindles of the drum of a cotton picking machine (Tashkent) p 16
[22] Dadazhanov Sh D 1968 Study of operation second pairs of drums of a harvesting apparatus of vertical-spindle cotton harvesting machines (Tashkent) p 31
[23] Karimov K B 1989 J Mech. of Cotton Growing 7 10-2
[24] Aytpenov U K 1980 Research and substantiation of the main parameters of a small-sized cotton picker (Tashkent) p 16