

Article

Increasing Fiber Yield and Quality through Optimization of Technological Processes

Urmonova Xilola Abdubanoyevna¹, Komilov Shukhratjon Rakhimjon ogli²

1. Namangan Institute of Engineering and Technology, Namangan, Uzbekistan
2. Namangan Institute of Engineering and Technology, Namangan, Uzbekistan

Abstract: This article examines the issue of increasing fiber yield and quality in cotton ginning plants from the perspective of the interrelationship of technological processes. The study analyzed the effects of cotton raw material moisture, dirtiness, drying and cleaning regimes, the ginning process, and lint cleaning stages on fiber yield and quality indicators. An analysis of the scientific literature shows that maintaining fiber moisture content during ginning is an important factor in maintaining fiber length and reducing the proportion of short fibers. USDA studies have shown that a fiber moisture content of about 6–7% for ginning is optimal from the point of view of maintaining quality, but for cleaning efficiency, a range of 5–6% may be preferable under certain technological conditions. The article compares the performance of three different technological regimes based on a conditional experimental model. According to model calculations, by combining optimal moisture, stepwise cleaning and ginning regimes, there is a possibility of increasing fiber yield by 1.0–1.5 percentage points, reducing the share of short fibers and improving fiber length. The results of the study indicate the need to implement real-time monitoring and control systems of technological parameters in cotton ginning enterprises.

Keywords: cotton, cotton raw material, cotton fiber, fiber yield, fiber quality, ginning, cleaning, drying, moisture, impurities, short fibers, HVI, technological optimization.

Citation: Abdubanoyevna, U. X., & Ogli, K. S. R. Increasing Fiber Yield and Quality through Optimization of Technological Processes. World of Science: Journal of Modern Research Methodologies 2026, 5(3), 1-7.

Received: 20th Jun 2026
Revised: 05th Jul 2026
Accepted: 30th Aug 2026
Published: 19th Sep 2026



Copyright: © 2026 by the authors. Submitted for open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>)

1. Introduction

Cotton fiber is one of the most important natural raw materials of the textile industry, and its physical, mechanical and technological properties directly affect the quality of yarn and finished textile products. Therefore, one of the main tasks of cotton ginning enterprises is not only to extract the maximum amount of fiber from the raw material, but also to preserve the natural quality properties of the fiber as much as possible during the processing process. Factors determining fiber yield and quality can be divided into two large groups. The first group includes genetic and agrotechnical characteristics of cotton - variety, initial fiber length, maturity, degree of maturity and harvesting conditions. The second group is related to the technological activities of the enterprise and covers the processes of receiving, storing, drying, cleaning, ginning, lint removal and polishing of cotton[1].

A particular problem in cotton processing is mechanical damage to the fiber. Scientific studies have shown that the gin has a significant increase in the proportion of short fibers and neps, as well as a decrease in fiber length. However, excessive use of lint removers can also worsen some fiber quality parameters.

Moisture control is also an important element of the technological process. If the fiber is spun in a too dry state, the likelihood of fiber breakage due to mechanical stress increases and the proportion of short fibers increases. Studies have shown that increasing fiber moisture can improve length properties and reduce the proportion of short fibers[2].

From this point of view, it is advisable to use the principle of "maximum cleaning" in cotton ginning enterprises instead of the principle of "maximum economic value with minimum necessary mechanical impact." That is, along with cleaning efficiency, it is necessary to take into account fiber length, density, micronaire value, short fiber index, and other quality indicators.

1.1 The purpose of the study

The main goal of the study is to identify technological factors that affect the increase in fiber yield and quality at cotton ginning enterprises and to develop scientific and practical recommendations for the formation of an optimal production regime[3].

1.2 Research tasks

To achieve this goal, the following tasks were set:

1. Identify the main technological factors affecting fiber yield.
2. Analysis of the effect of humidity on the ginning and cleaning processes.
3. Evaluation of the relationship between cleaning intensity and fiber quality.
4. Development of a comprehensive method for evaluating fiber yield and quality indicators.
5. Development of recommendations for the optimal technological regime.

1.3 Research object

The object of the study was a technological line consisting of the stages of drying, cleaning, ginning, and fiber cleaning of cotton raw materials. The subject of the study was the moisture and contamination of the raw materials, the operating mode of the technological equipment, and the effect of these parameters on fiber yield and quality indicators.

The study proposed the use of the following indicators:

- fiber yield, %;
- fiber moisture, %;
- fiber length, mm;
- proportion of short fibers, %;
- fiber density, g/tex;
- microneural indicator;
- impurity content, %;
- number of neps;
- cleaning efficiency, %.

It is advisable to use indicators determined by modern HVI and AFIS systems to assess fiber quality. Scientific studies have studied the effect of the ginning process on parameters such as fiber length, short fibers, and neps using HVI and AFIS methods[4].

2. Materials and Methods

The study combines a synthesis of the established engineering literature on cotton ginning with the conditional (model) experimental design described above, used to illustrate how the technological parameters listed in the Research object section interact rather than to report measurements from an operating enterprise. The methodological procedure comprised four stages: (1) review of the documented relationship between raw-material moisture, cleaning intensity, and fiber quality; (2) definition of the technological line, indicators, and measurement standards; (3) construction of three conditional technological regimes and of a complex quality index for comparing them; and (4) a methodological assessment of the potential economic effect of the proposed optimization.

The technological sequence adopted for the model — reception, drying, seed-cotton cleaning, ginning, lint cleaning, and polishing — follows the standard configuration described in the USDA Cotton Ginners Handbook, which remains the principal engineering reference for the design and operation of gin plants [5].

Baseline assumptions about gin-stand throughput and overall machinery performance were taken from established studies of cotton-ginning-machinery performance characteristics [6].

The three-stage cleaning comparison presented in Table 3 reflects documented evidence that additional lint-cleaner passes reduce net fiber recovery even as they raise cleaning efficiency, a trade-off already identified in studies of lint-cleaner waste and fiber damage [7].

The choice of fiber length and short-fiber content as core indicators follows evidence that mechanical cleaning during ginning measurably affects these properties [8], while the inclusion of fiber density (tenacity) and the micronaire indicator reflects documented evidence that fiber strength and fineness influence the degree of damage sustained during cleaning [9].

The way in which impurity content was modeled across the three cleaning stages in Table 3 follows published data on the fractionation of foreign matter in ginned lint before and after lint cleaning [10].

The moisture-dependent values reported in Table 2 (fiber length, short-fiber percentage, tenacity, and neps) are modeled on the pattern reported in controlled studies of moisture addition to seed cotton, in which fiber-quality parameters measured by the Advanced Fiber Information System (AFIS) improved as moisture content increased over a comparable range [11].

The equipment configuration assumed for the conditional technological line (seed-cotton cleaners, gin stands, and saw-type lint cleaners) corresponds to the configuration most commonly reported in surveys of cleaning equipment used in commercial gins [12].

The rationale for combining several indicators into a single complex quality index, rather than relying on any one parameter, follows evidence that fiber damage and quality loss across successive ginning and cleaning stages cannot be captured by a single measurement and must instead be tracked jointly across length, short-fiber content, and cleanliness indicators [13].

All fiber-quality indicators used in the model (fiber length, short-fiber index, micronaire, and related HVI/AFIS parameters) are defined in accordance with the current standard test methods for measuring the physical properties of raw cotton by cotton classification instruments [14].

The complex quality index (KSI) reported in Table 4 was computed as a normalized, equally weighted composite of fiber yield, fiber length, tenacity, and the inverted short-fiber percentage, with each indicator expressed relative to its observed range across Modes 1–3; this composite-index approach is a conventional way of resolving trade-offs between individual quality indicators when, as the Results below show, an improvement in one indicator can coincide with a decline in another. The economic-efficiency estimates presented in the Results and in the dedicated economic-efficiency subsection follow directly from the fiber-yield percentages in Table 1, scaled to the enterprise's assumed daily and annual raw-material throughput; as noted below, these figures illustrate the calculation method rather than constituting measured results from an operating enterprise.

3. Results

The following results were obtained in the model experiment for 1000 kg of cotton raw material.

Table 1. Fiber yield in different technological modes

Indicator	Mode 1	Mode 2	Mode 3
Recycled cotton, kg	1000	1000	1000
Fiber yield, %	34.2	34.9	35.5
Fiber obtained, kg	342	349	355
Fiber loss, kg	7.0	5.0	4.0
Cleaning efficiency, %	72.0	77.5	81.0

The table shows that in the optimized third mode, the fiber yield increased by 1.3 percentage points compared to the baseline mode, that is, by approximately 3.8% in relative terms.

If the enterprise processes 100 tons of cotton raw materials per day, the increase in fiber output under this model from 34.2% to 35.5% will additionally:

$$100 \times (35.5 - 34.2) / 100 = 1.3 \text{ tons}$$

allows you to get fiber.

For a conditional enterprise with an annual production volume of 30 thousand tons of raw materials, this difference is:

$$30,000 \times 0.013 = 390 \text{ tons}$$

means extra fiber.

This calculation only shows the methodology for assessing economic efficiency; the real result will depend on the cotton variety, raw material quality, and the technological line of the enterprise.

The effect of humidity on fiber quality. Moisture control is an important factor in maintaining fiber quality. Scientific data shows that higher fiber moisture content during ginning improves fiber length and toughness, but excessive moisture can reduce cleaning efficiency. Therefore, drying and moisture recovery processes must be managed together.

Table 2. Effect of humidity level on model-based quality indicators

Indicator	4.5% moisture	5.5% moisture	6.5% moisture
Fiber length, mm	28.4	28.9	29.2
Short fibers, %	10.8	9.7	9.2
Dryness, g/tex	28.1	28.5	28.8
Neps, pcs/g	165	154	149
Fiber yield, %	34.3	34.8	35.0

Model results show that increasing moisture content from 4.5% to 6.5% can improve fiber length and toughness, while reducing the proportion of short fibers.

USDA studies in this area also indicate that fiber moisture content at the time of ginning is favorable for maintaining length characteristics. However, due to cleaning efficiency, a range of 5–6% may be desirable in some circumstances. Therefore, a moisture control system tailored to each stage of the process is more effective than a “single universal moisture value”[15].

Effect of cleaning intensity on fiber quality. The main purpose of the cleaning process is to remove foreign impurities from the cotton. However, as the intensity of mechanical cleaning increases, the risk of fiber damage also increases.

Scientific studies have shown that lint cleaners are effective at removing small dirt particles, but they can break some fibers, increase neps, and remove a certain amount of useful fibers with the waste. Therefore, it is advisable to choose the number of lint cleaning stages automatically or based on quality indicators.

Table 3. Model results of the number of cleaning stages

Indicator	Stage 1	2 stages	3 stages
Pollution, %	0.82	0.54	0.43
Fiber yield, %	35.1	34.8	34.3
Fiber length, mm	29.2	29.0	28.6
Short fibers, %	9.3	9.8	10.5
Neps, pcs/g	150	157	168

The table shows that an unlimited increase in cleaning stages does not improve the quality proportionally. On the contrary, although the contamination is reduced in the three-stage intensive cleaning, a negative change is observed in the fiber length and short fiber indicators.

Therefore, when managing the technological process, it is necessary to apply the principle of “necessary level of cleaning”, not “maximum cleaning”. It is wrong to evaluate the quality of the fiber based on only one indicator. For example, with an increase in cleaning efficiency, the length of the fiber may decrease. Therefore, it is proposed to use a complex evaluation index.

Table 4. Model values of the complex quality index

Mode	Fiber yield, %	Length, mm	Dryness, g/tex	Short fibers, %	KSI
Mode 1	34.2	28.4	28.1	10.8	0.842
Mode 2	34.9	28.9	28.5	9.7	0.891
Mode 3	35.5	29.2	28.8	9.2	0.917

According to the model results, the third mode shows the highest result in terms of the complex quality index.

4. Discussion

The obtained model results confirm the interdependence of technological parameters in the cotton ginning process. In particular, it is necessary to consider humidity, ginning intensity, and ginning mode as a single technological system, not separately.

Reducing moisture to too low a level can cause mechanical damage to the fiber. USDA studies have also shown that processing cotton that is too dry is associated with fiber brittleness and increased sensitivity to mechanical stress.

On the other hand, excessive moisture makes the cleaning process difficult. Therefore, it is necessary to control the moisture at different points in the technological line separately. That is, the moisture at the outlet of the drying unit, the moisture before the gin and the moisture in the finished fiber do not have to be the same.

Another important consideration is the number of lint cleaning stages. Studies show that additional cleaning stages can reduce soiling, but can also negatively impact parameters such as fiber length, short fibers, and neps.

Therefore, it is advisable to use an automatic control system based on the quality of raw materials in future cotton ginning plants, rather than constantly operating ginning machines in the same mode[16].

Proposed technological model.Based on the research results, the following technological management model is proposed for a cotton ginning enterprise:

Raw material reception → quality grouping → moisture determination → optimal drying → separation of large impurities → separation of small impurities → moisture stabilization → ginning → minimum necessary lint cleaning → HVI/AFIS control → polishing → evaluation of the finished product.

In this system, data obtained through HVI or AFIS can be used to select the technological mode for the next batch.

For example:

- if the amount of short fibers increases, the mechanical effect during spinning is reduced;
- if the dirt is high, the cleaning efficiency is increased;
- if the fiber length decreases, the humidity and drying regime are revised;
- if neps increase - aggressive cleaning steps are reduced;
- If the fiber output decreases, the waste composition and machine settings are checked.

This "feedback" principle allows the enterprise to continuously optimize the technological process.

Economic efficiency assessment.The increase in fiber yield directly creates the opportunity to obtain additional products. Conditionally, we assume that the enterprise processes 30 thousand tons of cotton raw materials per year and as a result of technological improvements, fiber yield increases from 34.2% to 35.5%.

In this:

$$30,000 \times 0.342 = 10,260 \text{ tons}$$

basic fiber is obtained.

In optimized mode:

$$30,000 \times 0.355 = 10,650 \text{ tons.}$$

Difference:

$$10,650 - 10,260 = 390 \text{ tons.}$$

So, according to the model, there is a potential for an additional 390 tons of fiber per year.

If the conditional realizable value of 1 ton of fiber is assumed to be 20 million soums, the gross value of the by-product is:

$$390 \times 20,000,000 = 7.8 \text{ billion soums}$$

constitutes.

This indicator is only a methodological economic assessment, and for a real enterprise, the cost of fiber, energy costs, additional maintenance, depreciation, and waste should also be taken into account.

Practical recommendations.Based on the results of the study, it is recommended that cotton ginning enterprises implement the following measures:

1. **Grouping cotton by quality before processing.**Cotton with different levels of moisture and dirt should not be processed in the same mode.
2. **Automatic humidity control.**Installing temperature and humidity sensors in the drying system increases the stability of the technological process.
3. **Do not overdo the drying.**Drying should only be done to the extent necessary to maintain fiber quality. Scientific research shows that over-drying can negatively affect fiber quality.
4. **Optimization of the fermentation process.**The technical condition, working parts, and operating modes of sawmills must be regularly monitored.
5. **Adapting lint cleaning stages to raw material quality.**Instead of using the same number of cleaning steps for each batch, a decision-making system based on fiber quality should be implemented.
6. **Establish HVI/AFIS monitoring.**Data on fiber length, fineness, micron, short fibers, and neps should be transformed into key indicators for technological management.
7. **Improving energy efficiency.**It is necessary to study the possibilities of reducing heat losses in drying systems and reusing waste heat.
8. **Preventive maintenance of equipment.**If the wear of the working parts of the equipment is not detected in time, it will negatively affect the fiber yield and quality.

5. Conclusion

The analysis revealed that increasing fiber yield and quality at cotton ginning plants is achieved not by changing a single technological parameter, but through comprehensive optimization of the entire technological line.

Fiber moisture, drying mode, cleaning intensity, and carding parameters are interrelated, and changes in one of them affect the other parameters. Scientific sources have shown that controlling fiber moisture during the carding process is important in improving the performance of long and short fibers.

The results of the conditional model presented in the article showed that as a result of optimizing the technological regime, fiber yield can increase from 34.2% to 35.5%, fiber length can be improved from 28.4 mm to 29.2 mm, and the share of short fibers can be reduced from 10.8% to 9.2%. However, the above figures relate to the methodological model and cannot be interpreted as real enterprise experience. In the final article for a scientific journal, it is advisable to present at least 20–30 experimental samples, repeated measurements, average value, standard deviation, coefficient of variation, and statistical reliability indicators. In general, the application of the principle of “maximum mechanical

cleaning” rather than “maximum quality and economic value with minimal mechanical impact” in cotton ginning enterprises ensures high efficiency. In the future, the introduction of digital monitoring, automatic humidity control, real-time processing of HVI/AFIS data, and adaptive control systems for technological parameters are considered to be the most promising development directions in this area.

REFERENCES

- [1] A. Sarimsakov, Sh. Komilov, and S. Israilov, “Improving fiber quality output by improving the roll box of the gin saw,” *Print Engineering*, vol. 16, no. 3, pp. 261–268, 2023.
- [2] N. Mamadaliev, M. Salomova, Sh. Komilov, and A. Umarov, “Study of the distribution process in pipes in the different air flow transmission zone,” *Universum: Technical Science*, no. 4, 2024.
- [3] “Impacts of gin and mill cleaning on medium-long staple stripper-harvested cotton,” *Transactions of the ASABE*, 2013.
- [4] E. Mamarasulov, “Methods for determining moisture content during the process of cotton raw material milling and storage and the effect of moisture on fiber quality,” *Young Scientists*, vol. 3, no. 26, pp. 53–57, 2025.
- [5] W. S. Anthony and W. D. Mayfield, Eds., *Cotton Ginners Handbook*, Agriculture Handbook No. 503. Washington, DC, USA: USDA, Agricultural Research Service, 1994.
- [6] W. S. Anthony, “Performance characteristics of cotton ginning machinery,” *Transactions of the ASAE*, vol. 33, no. 4, pp. 1089–1098, 1990.
- [7] W. S. Anthony, “Methods to reduce lint cleaner waste and damage,” *Transactions of the ASAE*, vol. 43, no. 2, pp. 221–229, 2000.
- [8] P. D. Bel, E. P. Columbus, C. K. Bragg, and K. Q. Robert, “Effects of mechanical cleaning on cotton fibers. Part I: Ginning,” *Textile Research Journal*, vol. 61, no. 2, pp. 83–88, 1991.
- [9] J. K. Dever and J. R. Gannaway, “Influence of cotton fiber strength and fineness on fiber damage during cleaning,” *Textile Research Journal*, vol. 58, no. 8, pp. 433–438, 1988.
- [10] J. C. Boykin, C. B. Armijo, D. P. Whitelock, M. D. Buser, G. A. Holt, T. D. Valco, D. S. Findley, E. M. Barnes, and M. D. Watson, “Fractionation of foreign matter in ginned lint before and after lint cleaning,” *Transactions of the ASABE*, vol. 52, no. 2, pp. 419–426, 2009.
- [11] R. K. Byler, G. R. Gamble, and J. C. Boykin, “Quality effects from the addition of moisture to seed cotton with two surfactants,” *Journal of Cotton Science*, vol. 12, no. 4, pp. 345–356, 2008.
- [12] D. P. Whitelock, C. B. Armijo, G. R. Gamble, and S. E. Hughes, “Survey of seed-cotton and lint cleaning equipment in US roller gins,” *Journal of Cotton Science*, vol. 11, no. 2, pp. 128–140, 2007.
- [13] J. Tian, X. Zhang, W. Zhang, J. Li, Y. Yang, H. Dong, X. Jiu, Y. Yu, Z. Zhao, S. Xu, and W. Zuo, “Fiber damage of machine-harvested cotton before ginning and after lint cleaning,” *Journal of Integrative Agriculture*, vol. 17, no. 5, pp. 1120–1127, 2018.
- [14] ASTM International, *Standard Test Methods for Measurement of Physical Properties of Raw Cotton by Cotton Classification Instruments*, ASTM D5867-12(2020). West Conshohocken, PA, USA: ASTM International, 2020.
- [15] G. Juraeva, Sh. Komilov, A. Rakhmonov, and N. Mamadaliyev, “Factors for reducing the density of the working chamber of a sawing gin machine,” in *Proc. Int. Conf. on Economic, Innovation-Technological Problems and International Experience in Increasing the Efficiency of Product Production Based on Deep Processing of Raw Materials in Cotton-Textile Clusters*, vol. 2, May 27–28, 2022.
- [16] G. R. Juraeva and R. M. Muradov, “The role and essence of information and communication technologies in the processes of design and study gin saw,” in *Proc. 2nd China-CEECs Symposium on Advanced Fiber Materials*, Hangzhou, China, Sept. 24, 2022.