

"TECHNOLOGICAL FOUNDATIONS OF INDUSTRIAL HEMP CULTIVATION AND HOMOGENEOUS FIBER PRODUCTION IN THE SOIL-CLIMATIC CONDITIONS OF SURKHANDARYA REGION"

Q. Jumaniyazov¹, M.R. Mo'minov¹, A.Urazov²

¹ Institute of Fiber Crops Research

² Termez State University of Engineering and Agrotechnologies

Abstract This thesis highlights the results of studying the morphological, anatomical, and physico-mechanical properties of stalks of modern drug-free (non-narcotic) Middle Russian hemp varieties, as well as substantiating resource-saving technological processing schemes. The study scientifically substantiates the technical and biological ripening indicators of the "Ingreda" and "Yuliana" varieties, changes in phloem and fiber properties along the stalk length, and the technological, environmental, and economic efficiency of obtaining homogeneous hemp fiber (one-type hemp) using a disintegrator and a new separation device.

Keywords: *Hemp (Cannabis sativa L.), hemp fiber (пенька), phloem fiber, disintegrator, separation, shive-fiber mixture, technical length, inflorescence, resource-saving technology.*

1. INTRODUCTION AND RELEVANCE OF THE PROBLEM

In recent years, global demand for natural and environmentally safe raw material sources—specifically cellulose and textile fibers—has increased significantly. Among fiber crops, hemp stands out due to its high yield, rapid renewability, and resource-conserving properties. The cellulose content in hemp stalks is 5–7 times higher than that of wood, and its crop reproduction cycle is 20–30 times shorter.

Currently, developed countries such as China, Canada, France, Germany, and the USA produce nearly 25,000 types of products from hemp fiber and shives (hurd)—including textiles, composite materials for automotive and construction industries, biofuels, paper, and medical supplies. However, because this industry was restricted for many years, traditional machine-technology systems for processing stalks and extracting fiber have become morally obsolete, requiring high energy and labor inputs.

The objective of this study is to substantiate a resource-saving, low-cost, and high-productivity technological process for obtaining homogeneous hemp fiber (one-type hemp), taking into account the structure and properties of the stalks of new drug-free hemp varieties.

2. RESEARCH METHODOLOGY AND OBJECTS

The research objects comprised monoecious drug-free hemp varieties "Ingreda" (yellow-stemmed) and "Yuliana" (green-stemmed), bred by the Chuvash Agricultural Research Institute and included in the State Register of Breeding Achievements. The following methods and tools were utilized during the research:

1. **Morphological and Anatomical Analysis:** Total and technical stalk length, stalk diameter (at the butt/base, middle, and top portions), inflorescence length, internode distances, and leaf scar counts were evaluated in accordance with GOST 27024-86 and microscopic analysis tools (R20 microscope).
2. **Physico-Mechanical and Decortication Properties:** Breaking load of phloem and fiber (on an IR 5062-0.5 tensile testing machine), linear density (tex), flexibility (on a гибкомер/flexibility meter), and the degree of fiber separation from woody core (using a modernized OOV device) were determined.
3. **Mathematical Modeling and Statistical Analysis:** Collected experimental data were statistically processed using MathCAD 14, STATISTICA 6.0, and MS Excel software.

3. RESEARCH RESULTS AND ANALYSIS

3.1. Morphological and Anatomical Features of Modern Hemp Varieties

Conducted research revealed that the new drug-free varieties "Ingreda" and "Yuliana" differ significantly from previously studied traditional varieties. The main morphological indicators are presented in Table 1.

Table 1.

Morphological indicators of hemp varieties

Indicators	"Ingreda" (Technical ripeness)	"Yuliana" (Technical ripeness)	"Ingreda" (Biological ripeness)	"Yuliana" (Biological ripeness)
Total length, cm	173.6 ± 2.4	165.7 ± 3.22	179.8 ± 2.50	216.7 ± 8.70
Technical length, cm	81.5 ± 3.40	94.9 ± 2.70	100.9 ± 2.80	167.6 ± 6.40
Inflorescence length, cm	92.1 ± 2.80	59.8 ± 4.10	78.9 ± 5.00	49.1 ± 3.30

Share of inflorescence in total length, %	53.0	36.1	43.8	22.6
---	------	------	------	------

Anatomical and morphological analysis indicated that the inflorescence portion in these new varieties constitutes a very high proportion of the plant, accounting for **36% to 53%** of the total stalk length. Due to the high concentration of leaf and branch scars in the inflorescence zone, the integrity of the phloem and fiber structure is disrupted. Consequently, the tensile strength and flexibility of the fiber in the inflorescence portion are significantly lower compared to the fiber in the technical length zone.

3.2. Physico-Mechanical and Decortication Properties of Phloem and Fiber

Experiments conducted along the stalk length demonstrated substantial non-uniformity in fiber properties. Primary fibers predominate in the butt (lower) and middle parts of the stalk, exhibiting high strength, whereas secondary fibers prevail in the top (inflorescence) section.

- **Breaking Load:** The breaking strength of fiber from the technical stalk length is 1.8 to 2.4 times higher than that from the inflorescence portion.
- **Degree of Decortication:** During the process of cleaning stalks from shives (woody core), the core and fiber separate easily in the technical length, whereas separation is difficult in the inflorescence zone due to intertwined branches, causing this section to convert into excessive waste (shive-fiber mixture) during traditional scutching.

Therefore, processing the entire intact stalk under a single uniform mode is technologically impractical.

4. NEW TECHNOLOGICAL SCHEME AND MACHINE REQUIREMENTS

Based on the obtained scientific results, a new, cost-effective, and resource-saving technological scheme for processing hemp stalks has been proposed.

4.1. Stalk Fractionation and Disintegrator Processing

1. **Stalk Separation:** Prior to processing, raw stalks should be divided into two separate sections: the *inflorescence* portion and the *technical length* portion.
2. **Optimal Cutting Size (Discretization):** Theoretical and experimental studies demonstrated that cutting stalks into **55–60 cm** segments before feeding them into the disintegrator for shive removal represents the most rational parameter.

3. **Application of Disintegrators:** Replacing traditional scutching units with high-speed disintegrator machines operating on the principle of impact and sliding bending is recommended. This equipment effectively separates fiber from shives without damaging the fiber, while consuming significantly less energy.

4.2. Separation Device for Shive-Fiber Mixture

The material emerging from the disintegrator contains substantial amounts of loose shives and dust. To clean this mixture, a novel **separation device** equipped with active working elements was developed.

- **Operating Principle:** Under the combined influence of airflow and centrifugal inertial forces, fibers are retained on mesh and conical surfaces, while heavy and fine shive particles fall into the lower hopper.
- **Environmental and Technological Advantages:** This device eliminates the need for traditional cyclones. Dust emissions into the environment are prevented, and the shive content (закостренность) of the material directed to the subsequent shaking machine is reduced from 250–270% down to 110–130%.

5. TECHNOLOGICAL AND ECONOMIC EFFICIENCY

The industrial implementation of the proposed machine-technological scheme yields the following technical and economic benefits:

1. **Reduction in Metal and Energy Consumption:** Compared to complex traditional units (such as KP-3, KP-4, and breaking-scutching complexes), the metal intensity of the production line is reduced by 40–50%, and electrical energy consumption decreases by 30–35%.
2. **Fiber Yield and Quality:** The yield of homogeneous (one-type) hemp fiber increases by 15–20%, and fiber uniformity improves significantly, expanding its application potential beyond technical goods into textiles and industrial composites.
3. **Economic Impact:** The production cost of 1 ton of finished hemp fiber is reduced by 22–25%, significantly enhancing overall enterprise profitability.

6. GENERAL CONCLUSIONS

1. It has been proven that due to the high proportion of inflorescence (36–53%) and the high density of leaf scars in modern drug-free varieties "Ingreda" and "Yuliana", substantial non-uniformity exists in stalk and fiber properties along the plant length.
2. Fractionating hemp stalks into inflorescence and technical sections prior to primary processing and processing 55–60 cm cut segments in a disintegrator was established as the most rational resource-saving technology.

3. The newly developed separation device operating on aerodynamic and inertial forces effectively cleans the shive-fiber mixture, minimizes dust pollution, and ensures environmental safety.
4. Homogeneous hemp fiber (one-type hemp) obtained through the developed technological scheme serves as a highly efficient import-substituting raw material for textiles and industrial composite manufacturing.

REFERENCES

1. Zimniewska M. Hemp Fibre Properties and Processing Target Textile: A Review. **Materials**. 2022;15(5):1901. DOI: 10.3390/ma15051901.
2. Feigel B., Robles H., Nelson J., Whaley J.M.S., et al. Assessment of Mechanical Property Variation of As-Processed Bast Fibers. **Sustainability**. 2019;11(9):2655. DOI: 10.3390/su11092655.
3. Sankari H.S. Comparison of bast fibre yield and mechanical fibre properties of hemp (*Cannabis sativa* L.) cultivars. **Industrial Crops and Products**. 2000;11(1):73–84. DOI: 10.1016/S0926-6690(99)00038-2.
4. Vandepitte K., Vasile S., Vermeire S., Vanderhoeven M., Van der Borgh W., Latré J., De Raeve A., Troch V. Hemp (*Cannabis sativa* L.) for high-value textile applications: The effective long fiber yield and quality of different hemp varieties, processed using industrial flax equipment. **Industrial Crops and Products**. 2020;158:112969. DOI: 10.1016/j.indcrop.2020.112969.
5. Leoni M., Musio S., Croci M., Tang K., Magagnini G.M., Thouminot C., Müssig J., Amaducci S. The effect of agronomic management of hemp (*Cannabis sativa* L.) on stem processing and fibre quality. **Industrial Crops and Products**. 2022;188:115520. DOI: 10.1016/j.indcrop.2022.115520.
6. Hobson R.N., Hepworth D.G., Bruce D.M. Postharvest Technology: Quality of Fibre Separated from Unretted Hemp Stems by Decortication. **Journal of Agricultural Engineering Research**. 2001;78(2):153–158. DOI: 10.1006/jaer.2000.0631.
7. Zhukova S.V. **Investigation of New Hemp Varieties and Development of Technology for Obtaining Uniform Hemp Fiber** [Исследование новых сортов конопли и разработка технологии получения однотипной пеньки]. Candidate of Technical Sciences dissertation. Kostroma; 2012. Specialty 05.19.02 – Technology and Primary Processing of Textile Materials and Raw Materials.
8. Grégoire M., Barthod-Malat B., Labonne L., Evon P., De Luycker E., Ouagne P. Investigation of the potential of hemp fibre straws harvested using a combin