Improving the efficiency of the flax complex in Novgorod region

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Abstract. The paper considers the problems of fiber flax production in Novgorod region. The directions of increasing the efficiency of the flax complex are proposed. Options for shive application are analyzed. A project for organizing the production of fuel briquettes from shives in a flax mill is proposed.

1. Introduction
Fiber flax has been cultivated in Novgorod region for a long time. Unique properties of flax allow its use in various sectors of the economy. Linen fabrics are hygienic due to hygroscopicity and air permeability as they quickly absorb and release moisture to the skin. Flaxseed oil produced from seeds contains valuable unsaturated acids, vitamins and minerals.

Flax by-products: chaff is used to feed animals and as organic fertilizers, shive is used to make high-quality paper and environmentally friendly heat-insulating construction and structural materials. Short fiber is used in construction of buildings with increased noise insulation, retaining heat and durability. Practical use of the flax stem is 95÷96% of its mass. The study aims to improve the efficiency of flax production in Novgorod region.

2. Materials and methods
System analysis of the technological and technical base of flax growing in Novgorod region has been performed.

3. Main part
Despite valuable properties of flax fiber and oil, fiber flax production has significantly decreased. At present, the area under this commercial crop in the main flax-growing regions of Russia has decreased 12–15-fold.

A long-term regional target program [1] shows that the development of flax growing is affected by the absence of textile enterprises in the region that would end the cycle agricultural producer – flax mill – buyer of finished products.

Natural and climatic conditions in Novgorod region are favorable for fiber flax cultivation. The sown area of fiber flax in the region in 1989 amounted to 24,713 hectares (6.0% of the sown area), and in 2018 it was 1,500 hectares (1.0%) [2]. Farms in Novgorod region are currently engaged in production of fiber flax only in two districts: Shimsky and Soletsky districts. In the recent past, flax was cultivated in 19 districts of the region.
A decreased interest of rural producers in cultivation of fiber flax is related primarily to untimely payment for the products delivered by farms to flax mills. In addition, it is associated with a sharply increased cost of energy resources, and, hence, deterioration in the material and technical base of flax farms. According to Novgorodstat [2], 24.5 flax harvesters per 1,000 hectares of flax crops were recorded in 2000, and 3.2 flax harvesters worked in 2018.

The only flax mill in the region is located in the village of Utorgosh, Shimsky district. It was built in 1936 and is engaged in flax cultivation and processing.

The problem is not only reduced fiber flax production but also low quality of raw flax. The average number of long fiber produced by the flax mill is 9÷10, less often 11, and the textile industry needs flax fiber number 12 and higher. Firstly, this is due to low quality of flax stock, and secondly, it is caused by deterioration of the processing equipment.

Low quality of flax stock (its number does not exceed 1.0) is due to violated technologies of flax growing and harvesting. Crop rotations are disregarded; flax is cultivated on the same lands from year to year. Due to the lack of financial resources, an insufficient amount of mineral fertilizers is applied (10–15% of the required rate), and the lack of herbicides leads to crop contamination.

There is a shortage of quality seed material. In recent years, the yield of flaxseeds does not exceed 0.09÷0.10 t/ha due to the lack of equipment for flax cultivation and harvesting, natural and climatic conditions, and loss of immature seeds during harvesting. Flax-growing farms do not perform flax stripping [3]. These problems reduce the yield and quality of flax products. Deterioration of the technological equipment in the flax mill and unavailability of optimal modes of flax stock processing decreases the specific gravity of long fiber, which averages 20–30%.

At present, regional farms use a combine technology for flax harvesting. It has a number of advantages, including labor costs that do not exceed 70 man-h/ha for this technology. The disadvantage of combine harvesting is that seeds and fiber become mature at different times, and, therefore, high-quality seeds and fiber cannot be obtained simultaneously.

Separate technology is used for harvesting fiber flax, but it has not found application in the farms of Novgorod region. In contrast to combine harvesting, stripping and deseeding operations are performed in an interval of 5÷7 days. During this time, seeds in undeseeded pods ripen, their germination capacity increases by 8÷10%, and energy consumption for their drying decreases. However, this technology is highly dependent on weather conditions; in unfavorable weather, seeds can germinate and be completely lost.

Therefore, to solve these problems, fiber flax cultivation needs mastering resource-saving technologies. M.M. Kovalev in the reference book [4] recommends transition to a combined cleaning technology, which can be used in different weather conditions. For the early yellow ripening stage of fiber flax, a separate harvesting technology is used, and at the yellow ripening stage, a combine harvesting technology is employed.

Currently, the Republic of Belarus is mastering a commercial Western European technology of harvesting and primary processing of fiber flax [5]. This technology uses lines for primary flax processing in a flax mill (Van Dommele, Vanhauwaert, Depoortere) equipped with rippling machines. Fiber flax stripping is carried out in a short time at the optimal ripening stage, followed by harvesting of flax stock together with the seed pods with balers. The main disadvantage of the commercial technology is large loss of seeds both in the field during maturation of the flax stock and in the flax mill when the seed pods are deseeded.

Using of new machines both in the field and in the flax mill will increase profitability of flax production and primary processing due to long fiber and quality of flax. Flax stripping accelerates the aging process and yields flax stock with uniform fiber decortication and moisture content, and reduces the risk of rotting of the bottom layer. This technique improves the flax quality by 0.25÷0.50 of the number, improves breaking force, fineness, and fiber color. Low technological reliability of the wrappers slows down the pace of wrapping.
The efficiency of the industry can be increased through the use of in-depth processing of flax by production of deseeded and cottonized flax fiber, nonwovens, twisted products, flax shive boards, flax shive briquettes and other products [6].

Low-grade flax stock of fiber flax is not higher than 0.75 in flax factories account for up to 30% of the total weight of raw materials [7]. In order to maintain profitability, it is better to process this flax stock into short fiber of the same type. For primary processing of flax stock in the field, the KVL-1 flax harvester is used. The resulting fiber of the same type number two and below is used for production of heat insulators, nonwovens, cotton wool, cellulose, technical and medical wool and other materials.

During primary processing of flax stock, technologies should be differentiated [8]. A high quality flax stock of numbers 1.50 and above needs to be processed using high-tech equipment to increase the yield of long fiber. When processing low-quality flax stock, it is better to use less costly technologies for decortication using disintegrators, since processing of such flax stock using high-tech equipment will not be efficient.

To date, using flax shives, a by-product of primary flax processing, is an issue of high relevance for the flax mill. It makes up about 65% of the processed stock mass, of which about 60% is burned in the furnace room of the flax mill. However, a significant part of flax shives accumulates in the territory of the enterprise and becomes a source of fire hazard (figure 1).

![Figure 1. Shive storage at the enterprise.](image)

In this regard, processing of shives into various materials needed for industry, agriculture and the population is crucial. It is important to apply technologies for using shives in order to save energy and protect the environment. One of the areas of its application is the production of shive and wood-shive boards [6]. Special equipment installed can be used to produce environmentally friendly fuel (biofuel) from flax shives. Various options for use of the shive [6] are presented in figure 2.

The shive must be used as a fuel for generating electrical and thermal energy, fertilization of agricultural crops, and manufacturing of building insulation materials and products [9]. Boilers of various brands and manufacturers are installed in furnace rooms of flax mills, with the shive as the main source of fuel. The sorbent produced from flax shives can be used to purify air, water and oils.
Flax shives, low-grade short fiber and flax straw (of low quality) are used to manufacture fibrous semi-finished products used for production of paper, carton and other products. These products are superior to wood since they contain bast with high-quality cellulose [4]. In addition, the production process does not include energy-consuming process of preparing wood chips. Another important advantage of cellulose-containing raw materials from bast crops is its annual reproduction.

The analysis of the mill that does not have enough financial resources to implement expensive projects, for example, the production of shive boards, shows that the most rational solution is the production of fuel briquettes from flax shives.

Most flax mills are in a difficult financial situation and cannot raise loans due to the specifics of production [10].

At present, shives are fed to the furnace of the furnace room in bulk. The efficiency of burning shives in this form is not high. Therefore, the heat used for drying flax seeds in a rotary dryer and drying flax stocks is produced mainly by burning firewood.

Advantages of shive briquettes:
1) sustainability of fuel briquettes which are a natural raw material with lignin as a binder;
2) prolonged burning time and constant temperature throughout the entire combustion period;

**Figure 2.** Using of flax shives.
3) easier to feed into the furnace compared to shives or other waste stored in bulk;
4) low production cost;
5) high heating capacity: burning of 1 ton of shive briquettes produces the same amount of thermal energy as burning of 1.6 tons of wood, 478 m$^3$ of gas or 500 liters of diesel fuel;
6) low level of environmental pollution: CO$_2$ released into the atmosphere during combustion of shive briquettes is 10 times less than that of natural gas and 50 times less than that of coal;
7) use of combustion by-product (ash) as an environmentally friendly fertilizer;
8) suitable for all types of furnaces.

At present, various types of fuel briquettes are produced:
1. Bricks. They have a rectangular shape and dimensions of 65x95x150 mm. They got their name from the German manufacturer of hydraulic presses RUF. Pressing pressure $P = 300\div400$ bar.
2. Round briquettes. They are cylindrical in shape with a diameter of 60÷90 mm and a length of 50÷300 mm. They are produced using high-pressure mechanical and hydraulic presses ($P = 400\div600$ bar).
3. Pini-Kay briquettes. They are of a polyhedron shape with a characteristic dark crust and a hole in the center. Their dimensions are 50÷80x200÷300 mm. They got their name from the Austrian company Pini @ Kay. The production process includes not only pressing ($P = 1000\div1100$ bar) but also surface firing.

In addition, consider pellets, which are usually 6÷8 mm in diameter and 50÷70 mm in length. They are an alternative to briquettes, but pellets need to be used in specialized boilers. The equipment for their production is pellet presses.

The following types of presses are used to obtain briquettes and pellets:
1. The hydraulic press is used in small plants. The principle of operation is based on the pressure generated by fluid. The quality of the manufactured products is not always high.
2. The screw press provides high pressure on the manufactured product, but requires a high temperature regime. Briquettes are of high quality, high cost of equipment.
3. Impact mechanical press is widely used. The principle of operation is based on the transmission of impacts from the crank mechanism to the piston with a specified frequency. The piston pushes the product through the die that has been placed to the chamber.
4. The pellet press is used for production of pellets and requires preliminary grinding of raw materials to a minimum size and adding a binder to it.

The impact mechanical press is suitable for production of fuel briquettes made from flax shives. It exhibits simplicity of design, high productivity, and possibility of manufacturing briquettes of the required size. The shive can be fed to the press manually or in automatic mode with or without preliminary grinding.

The analysis of the environmental impact of the flax shive briquetting line carried out at Gorkilen OAO shows that production of briquettes is ecologically acceptable. The pollution control equipment Cyclone C 5, with a cleaning efficiency of at least 75%, reduces the emission of solid particles into the atmosphere, which is impossible when storing shives in bulk.

4. Results
A furnace room of the Utorgoshsky flax mill is used for drying seeds on a rotary dryer during flax harvesting and for drying flax stocks during its processing. For these purposes, firewood in the amount of 91.2 tons is burned in the furnaces of the furnace room along with shives.

The project aimed at production of fuel briquettes in this flax mill can be implemented within one month. The annual economic effect from the use of self-produced briquettes amounts to 327 thousand rubles, the payback period of the project is 1.4 years. The production of fuel briquettes from shives will increase the efficiency of fiber flax production and make primary processing of flax stocks almost waste-free.
5. Conclusion
The experience of developed countries shows an annual increase in the use of biofuel, therefore, the market for fuel briquettes produced from flax shives is unlimited. The briquettes can be used for all types of furnaces and central heating boilers, for heating passenger cars, storage and industrial premises, and furnace rooms that use solid fuel. Shive briquettes are in great demand among the population for use in fireplaces, stoves, grills, as it is a convenient, compact and ecological type of fuel.

References
[1] Long-term regional target program Development of the Flax Complex in Novgorod region in 2013–2020 approved by the Decree of the administration of Novgorod region #696 of 30.10.2012
[2] Statistical Yearbook of the Novgorod Region 2019 Novgorodstat p 335
[3] Golub I A 2017 Prospects for cultivation and processing of fiber flax in the Republic of Belarus Vesci Natsyanalnay Academicii Navuk Belarusi. Series of Agricultural Navuk (Minsk: Belaruskaya Navuka) 3 91–98
[4] Kovalev M M and Kolchina L M 2013 Technologies and equipment for the production and primary processing of flax and hemp (Moscow: FGBNU Rosinformagrotech) p 184
[5] Sharshunov V A 2015 Investigation of a threshing device in a primary flax processing line Vesti NAS Belarus. Series of Agricultural Science 3 112–117
[6] Kazakevich P P, Karpunin I I, Golub I A and Karpunin V I 2016 Improvement of production technologies and processing of fiber flax and oil flax (Minsk: Belaruskaya Navuka) p 184
[7] Soboleva E A, Bezbabchenko A V, Vnukov V G and Prokofieva S V 2020 Processing of low-grade fiber flax trunks into a similar type of fiber using a trailed flax-combine KVL-1 Agricultural Machines and Technologies 1 (14) 69–75
[8] Pozdnyakov B and Perov G 2017 The concept of construction of the technology of fiber flax production Science in the Central Russia 3 (27) 21–28
[9] Perepchechaev A, Karpunin V and Kislov T 2018 About the technologies of in-depth processing by flax factories flax-grass and low-cutting short fiber RUE SPC NAS of Belarus for Agriculture Mechanization (Minsk: Republic of Belarus) 81–85
[10] Tsymbalenko S N 2017 Improving the financial mechanism of the enterprises of the flax subcomplex of the Republic of Belarus Bulletin of BarSU. Series Historical Sciences and Archeology. Economic Sciences. Law Sciences 5 116–119