

## CUTTING OF THE BIOLOGICAL MASS OF INDUSTRIAL HEMP

### Summary

*Cutting industrial hemp at different stages of maturity is rather a complicated operation because of the hard fibre in its stalks, great specific cutting resistance, as well as high crop capacity and great length of the stalks. In order to find harvesters that are suitable for these purposes, comparative experiments have been conducted. The process of cutting hemp is most stable when finger bar mowers are used. The rotary (disk) mowers are of little use for cutting hemp due to the tendency of the stalks to wind up around the shafts and other rotating details. It is economically purposeful to use the fingerbar mower TEBECO Beagle 3.2 when the areas to be harvested are less than 50 ha but on smaller areas good results can be achieved by the duplex mower KD-210.*

**Key words:** industrial hemp, finger bar mower, costs

### 1. Introduction

Hemp is the most ancient agricultural crop and, according to a number of authors, it has been consumed by mankind already more than 10 thousand years. After cotton processing machines were invented in the 19<sup>th</sup> century, the areas under hemp started to decrease. However, sharp reduction in the areas under hemp set in after the adoption of the Marijuana Tax Act in the USA. According to the provisions of this law hemp (*Cannabis sativa* L.) was included into the list of the narcotic plants [1].

However, during the last 20 years an opposite tendency is observed in the world – an active growth in the areas under hemp. In addition to that, there is also strict control imposed in the EU, and those sorts are allowed to grow and receive subsidies which are with the contents of tetrahydrocannabinol (THC) – a psychoactive ingredient – not more than 0.2 %. From hemp having such a THC contents production of a narcotic substance is practically ruled out. In the EU countries industrial hemp (*Cannabis sativa* L.) is considered as one of the important renewable resources for the production of a wide range of industrial products (a witness of this is the Resolution of the EU Commission „COM/2008/03/07”). Specialists have calculated that, by the photosynthesis rate of the organic mass, 1 ha of hemp is equivalent to 4 ha of a forest. The major producers of hemp in Europe are France, Poland, the Netherlands, Germany. In Latvia massive growing of industrial hemp started since 2009.

Industrial hemp is grown to obtain fibre for textiles (denim, the CRAILAR material, etc.), canvas, valuable paper and banknotes, building and insulation materials, composite materials for automobiles and many other purposes (it is considered that hemp can be used to produce about several thousand different kinds of products) [2]. The by-product – sheave (chaff, shive, boon) – is actively used in Latvia as a building material, including for building ecologically pure houses with a high thermal insulation degree [3-5]. The seeds of industrial hemp is a valuable foodstuff and fodder product, and they are actively used in cosmetics and medicine as well. Considering its high crop capacity, hemp is of interest as an energetic crop, too.

The most complicated and labour intensive technological process in growing industrial hemp is its harvesting. The weather conditions in Latvia are essentially different

from those in Western Europe both by the vegetation periods and harvesting conditions. Harvesting of hemp determines 60-70% of the production profitability of this crop and the quality of the obtained product.

### 2. The object and methodology of research

The object of the research work is to evaluate suitability of different types of machines for cutting and disintegration of the hemp stalks at different stages of growth (maturity) and calculate the value of the operating costs for the best variants.

Investigations were conducted on production and experimental areas with the sorts Futura and Białobrzeskie of industrial hemp. The crop yield of the green mass was 38-65 t ha<sup>-1</sup> and the height of the plants was 2.5-2.9 m. The average diameter of the stalks was 7-9 mm, yet the diameter of some stalks reached 24 mm.

On the basis of well-known methodologies investigations of operating and technological parameters were carried out of three types of finger bar mowers for cutting the hemp stalks, and two rotating disk mowers.

The operating costs were determined in the accounts as the sum of personnel costs, the tractor fuel costs, repair and maintenance costs, and the amortisation costs of the machinery.

### 3. Results and discussion

Under the weather conditions of Latvia the maturity stage of hemp for its harvesting here falls in September but for harvesting the seedy part – even at the beginning of October [6-7]. In order to achieve normal and sufficiently fast ripening (maturing, aging) of the stalks in open air, harvesting should be carried out not later than in the second half of August. The time of complete ripening of seeds sets in later than maturing of the stalks for their harvest [8]. Depending on what the main purpose of the hemp production is (fibre, seeds, or both products) the harvesting times may be shifted a little.

In recent years new ways appeared how to use the stalky part of hemp in order to produce insulation plates for the furniture and building branches. For this purpose, finely disintegrated biological mass of plants is used as the basic component.

To produce (press) insulation plates for buildings from the biological mass of hemp, 25-30% of the dry mass with a 15-17% moisture content are used, 70-75% of the mass with a 0-85% moisture content (the natural moisture content of the stalks at the moment of their harvesting), and up to 10% of the binding material. The required basic strength properties of the plates are generally ensured by the stronger dry component, the wet component serving, to a great degree, as an ecological filling material. For this reason the requirements for keeping and the strength of the fibres of the moist component are comparatively lower. Therefore, from the viewpoint of weather conditions, the harvest of hemp to obtain the wet component can start in earlier and more favourable terms. At the blooming stage (in Latvia it is usually at the end of July or the beginning of August) the stalks of the plant are generally already mature and ready for harvesting the biological mass. It is followed mainly by the formation of the inner structure, accumulation of the fibres and the seedy part. Besides, this period of summer in Latvia has more favourable weather conditions allowing to carry out the work with a considerably lower risk that the product may be damaged. As the formation of the fibres in this blooming period in the stalks of the plants is still at the medium stage, their cutting resistance is essentially lower, and the harvesting and disintegration operations can be carried out by forage combine harvesters. In a conducted laboratory experiment relative cutting resistance of the stalks was estimated at different stages of their maturity. There were stalks used with diameters 7 and 12 mm, cut at the blooming stage, after 15 and 30 days. The cutting resistance of a wisp (from 20 stalks), equivalent by sectional area, of newly-cut hemp at the blooming stage was by 50-65% less than 30 days later.

Cutting industrial hemp at different stages of maturity is a rather complicated operation due to the presence of strong fibres, great cutting resistance of the thick and fibrous stalks, as well as high crop yields and great length of the stalks. In order to choose mowers, suitable for this purpose, comparative experiments have been carried out.

In our experiments there were used: a two-level finger bar mower TEBECO Beagle 3.2 for harvesting hemp (Fig. 1), a duplex finger bar mower KD-210 (Fig. 2), a finger bar mower KSF, and rotary mowers KDT-260 and BSC Rotex S5.

If the height of the stalks is more than 2.5-3 m, to simplify further processes of harvesting and processing, it is desirable that the stalk is cut into segments, to 1-1.1 m long.

Technical characteristics of mowers TEBECO Beagle

3.2 and KD-210 are presented in Table 1.

In order to investigate possibilities to apply rotary mowers for cutting hemp, a mower with flattening rolls was used, and the mower KDT-260. Experiments have shown that application of the most wide-spread types of rotary mowers for cutting significant areas of hemp (particularly, at the stage of full maturity) is practically of little use. The fibrous stalks wind around the rotating elements of the mower (shafts, etc.), which causes a need in technological equipment for cleaning the shafts (after each 200-300 m). Besides, there is great risk that the bearings of the rotating elements might be damaged. In spite of the high cutting speed (Fig.4), there appears no exact cut of the stalk under the impact of the knife without an abutment, i.e. there mostly arises a disruption of the stalk (a comparatively more energy intensive process).

The two-level finger bar mower TEBECO Beagle 3.2 cuts the stalk into two parts: the cutting length of the lower part is 100 cm and that of the upper part is 130-180 cm (depending on the length of the plants). The two-level mower does not ensure equal cutting length of the tall plants. Therefore the company TEBECO puts out also three-level mowers which ensure the cutting length of the stalks 80-110 cm (Fig. 4).

Among the cheaper range of universal finger bar mowers – less than 1500 EUR, the KD-210 -type duplex finger bar mowers show the best indicators by using of which it is possible to achieve a labour productivity of 1.4-1.9 ha h<sup>-1</sup> and ensure a cutting height of about 6-8 cm. In contrast to the ordinary finger bar mowers, the rotational velocity of the duplex mowers is two times greater; therefore it is possible to work with a greater operating speed, and, at equal operating widths, their efficiency is by 40-45% higher. A shortcoming of this mower is also absence of a possibility to cut the stalks into two parts.

These mowers cut well both – at the blooming stage and in a later period of harvesting (30 and 45 days later).

As, using the mower TEBECO Beagle 3.2, the stalks are cut into two segments (which is more convenient for their processing into fibres), it is possible to increase the purchasing price of the stalks under Latvian conditions to 40.0 EUR ha<sup>-1</sup>. Our calculation of the operating costs of the mowers (considering the possible difference in the purchasing price) shows that in case the area of the harvested hemp plantations is more than 50-65 ha, it is economically more purposeful to use the mower TEBECO Beagle 3.2 but for the areas less than 50 ha one can use a significantly cheaper mower of the type KD-210, or its analogue (Fig. 5).

Table 1. Technical and performance characteristics of mowers TEBECO Beagle 3.2 and KD-210

Parameters	TEBECO Beagle 3.2	KD-210
Type	Trailed, ordinary, with finger bars (segment-finger bar)	Trailed, duplex, with finger bars (segment-finger bar)
Number of cutting apparatus (cutting levels)	2	1
Operating width, m	3.0	2.1
Mass, kg	1950	225
Length of the first stalk cutting degree, cm	110	-
Clutch shaft frequency, min <sup>-1</sup>	540±5	540±5
Aggregated with a tractor, kN	14	6-9
Cutting height from the soil surface, mm	150-180	40-60
Labour productivity, ha h <sup>-1</sup>	3.9	1.8
Price, EUR	19800	1250

Source: Authors' own research



Fig. 1. A two-level hemp mower TEBECO Beagle 3.2 in operation



Fig. 2. A duplex mower KD – 210 in operation

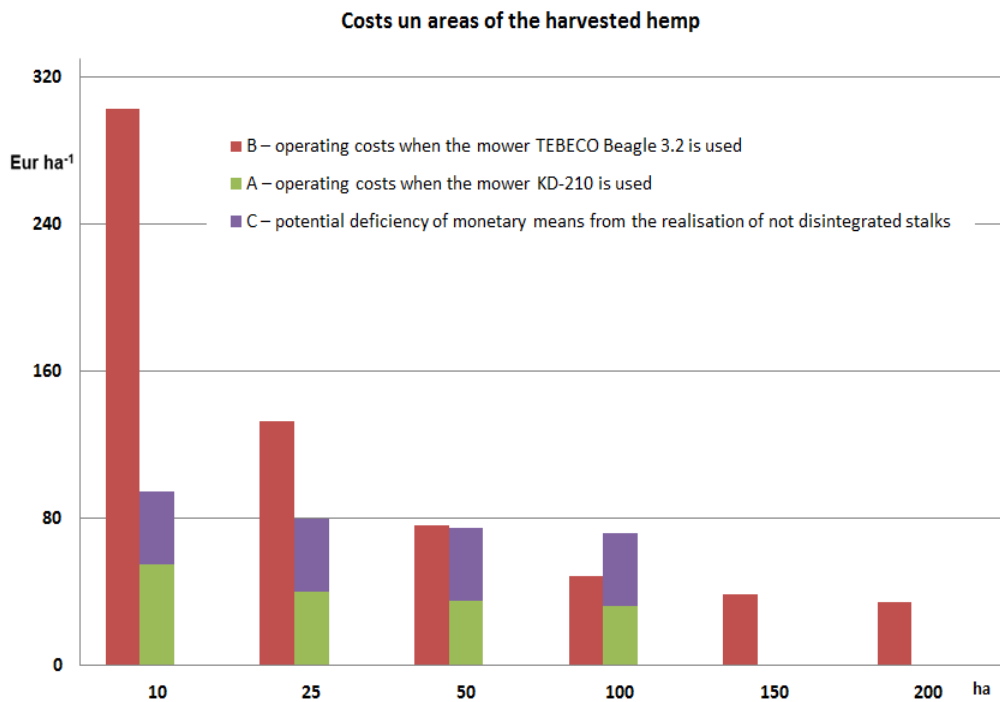


Fig. 3. A comparative view of the hemp stalks cut by a fingerbar mower (left) and a rotary mower (right)



Fig. 4. A three-level hemp mower TEBECO Beagle 3.3 in operation

Source: Authors' photos



Source: Authors' own research

Fig. 5. Operating costs of the mowers TEBECO Beagle 3.2 and KD-210 used on different areas of the harvested hemp

Application of expensive (more than 300 000 EUR) specialised hemp combine harvesters need great concentration of areas, and, as experience has shown, due to the high amortisation costs, they are of little efficiency for the time being (the servicing costs of the hemp harvest by such a combine harvester are 200 ha<sup>-1</sup>) [6].

The average cutting height of the mower TEBECO Beagle 3.2 was 18 cm and the cutting height of the mower KD-210 was 7 cm. At an average technical length of hemp 2.2 m this means a value of losses of the stalky mass accordingly 8.2% and 3.2%. In this case the height of the stalks and, hence, the corresponding values of losses depend on the design peculiarities of the header flotation units and the operation of the mowers. Under real conditions, when working with a great operating width at a high speed on an uneven microrelief, a greater cutting height of the stalks is necessary (to avoid striking of the projections of the soil with the cutting apparatus).

#### 4. Conclusions

1. The hemp cutting process is most stable when finger bar mowers are applied. The rotary mowers are of little use for the hemp harvest because the stalks tend to wind round the shafts and other rotating details.
2. The finger bar mower TEBECO Beagle 3.2 is economically more purposeful for the hemp harvest when the harvested area does not exceed 50-65 ha, but on smaller areas it is profitable to apply a disk duplex mower of the type KD-210.
3. The average cutting height of the mower TEBECO Beagle 3.2 was 18 cm and the cutting height of the mower KD-210 was 7 cm. At an average technical length of hemp 2.2 m, this means a value of losses of the stalky mass accordingly 8.2% and 3.2%.

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