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CONSIDERATIONS ON THE HYDRAULIC INSTALLATION OF THE EQUIPMENT FOR HARVESTING GREEN HEMP STALKS

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Abstract: *Considering that raw materials that meet the needs of the different areas of the economy with the lowest costs are sought, the reactivation of the hemp culture in Romania must be taken into consideration as well, because hemp (Cannabis Sativa L. - industrial hemp) is the industrial plant most widely used in the industry, and from this plant everything is used. The products obtained from hemp are of a great variety, from the common rope to the medicinal or cosmetic substances, textiles, automotive or construction materials. The fibres content in the stalks have a number of properties that are particularly valuable as (traction, torsion, friction, rot) resistance, extensibility (elastic and plastic), spinning capacity. In this paper we introduce an experimental model of towed technical equipment for harvesting green hemp stalks with hydraulic drive, designed, manufactured and tested by the specialists from INMA Bucharest. The paper presents the constructive-functional scheme, the functional description and the technical and functional characteristics of the Equipment for harvesting green hemp stalks ERCV-0. The ERCV-0 equipment is provided with a hydraulic installation with which the cutting devices, consisting of two knives placed at different heights and offset horizontally are operated, with the possibility of folding during transport. This equipment performs sequential harvesting of hemp stalks leaving them organised on the ground and it is intended for small and medium-sized farms, as required by many farmers who grow industrial hemp and they want the further processing of the stalks.*

Keywords*: Green hemp stalks, harvesting, hydraulic installation*

1. Introduction

Hemp (Canabis Sativa L. - industrial hemp) is the industrial plant most widely used in the industry. The products obtained from hemp are of a great variety, from the common rope to the medicinal or cosmetic substances, textiles, automotive or construction materials.
Considering that raw materials that meet the needs of the different areas of the economy with the lowest costs are sought, the reactivation of the hemp culture in Romania must be taken into consideration as well, because from this plant everything is used. Also, hemp is an unpretentious plant because, apart from the fact that it wants a neutral pH and soils without excess moisture, no maintenance work should be done and no extra care should be given, and the costs per hectare are below the costs of other well-known crops such as rape or wheat [1, 2, 3].
The fibre content in the stalks is influenced by the variety, by the technological and pedoclimatic conditions. Industrial hemp fibres have a number of properties that are particularly valuable as (traction, torsion, friction, rot) resistance, extensibility (elastic and plastic), spinning capacity [4, 5].
As demands for fibre appeared on the hemp market, farmers and researchers from research centres in our country want to make machines that allow them to harvest and process the stalks while green. Also, it is expected that in Romania the areas cultivated with hemp will grow in the next years, gradually becoming a basic culture also through the development of an adequate processing industry.
In this paper we introduce an experimental model of towed technical equipment for harvesting green hemp stalks with hydraulic drive, designed, manufactured and tested by the specialists from INMA Bucharest.

2.Material and methods

The hemp stalks, the component part that constitutes the object of the harvesting operation, is grassy at the beginning of the vegetation, green in colour, covered with rough hairs; at maturity, it is lignified and reaches heights of 1-7 m (depending on the origin, crop area and pedoclimatic conditions of the year), it has 5-25 internodes (depending on the origin), with the base diameter of 0.5-6 cm and is not branched in fibre crops and weakly branched in seed crops (depending on crop form, variety and nutrition space).
The main characteristics of hemp stalks are: length, thickness, colour, resistance to diseases and pests' attack, resistance to mechanical injuries (hail, broken or crushed stalks), breaking load. Knowing the importance of each characteristic allows predicting, to a large extent, according to the outer appearance of the stalks, their behaviour in the technological process of primary processing, as well as the probable results of the processing, both quantitatively and qualitatively. The quantity and especially the resistance of the fibres can be appreciated by the mechanical characteristics of the stalks, respectively by their resistance to breaking [6]. In cases of serious injuries (rotting, retting in the field, severe disease attack), the stalks have a low resistance, they can be easily broken, even by hand. The fibre hemp is harvested at technical maturity, when the male plants shake their last pollen traces, and the stalks have a greenish-yellow colour and the leaves fallen to the ground.
The industrial hemp harvesting is done by cutting both mature male plants and female plants that are in the vegetation phase. The production of stalks is on average 5-6 t/ha, but can reach up to 10-12 t/ha dry stalks. The amount of fibres obtained per hectare, after processing the stalks, represents 16-30% of the stalk production. Usually, the stalks are cut in mid-August and left lying on the ground for 4 to 6 weeks, depending on the weather.
INMA Bucharest comes to the aid of the farmers who cultivate industrial hemp, by designing and realizing the Equipment for harvesting green hemp stalks ERCV-0, of trailed type (figure 1: a, b).

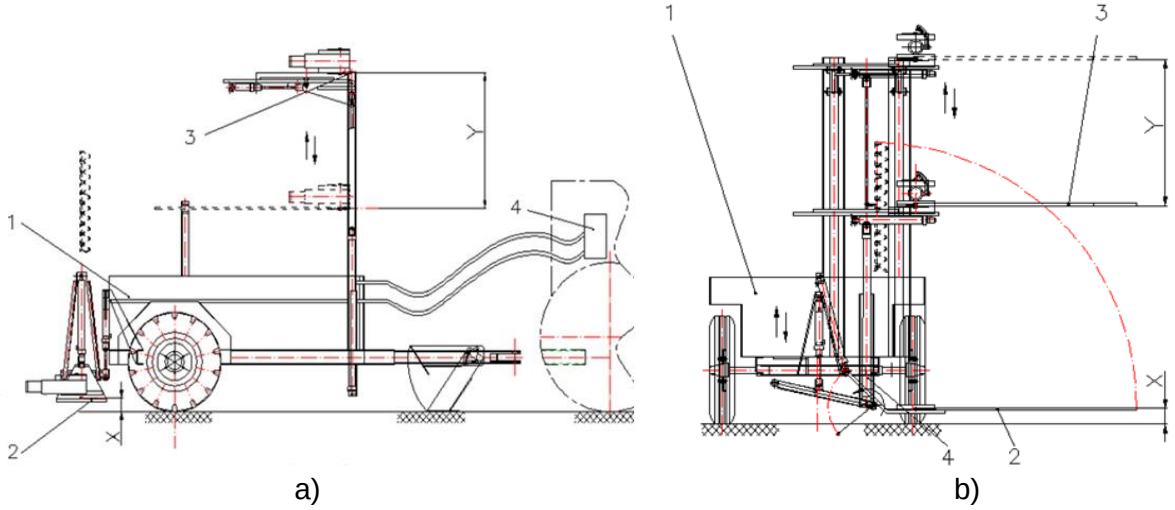

Fig. 1. Equipment for harvesting green hemp stalks ERCV-0- experimental model [7]
a) –lateral view; b)–rear view
1-assembled mobile platform; 2,3 knives; 4-hydraulic installation

The assembled mobile platform (pos. 1), is a metallic construction, towed semi-trailer type, on which are mounted 2 movable arms, components that support the two sequential cutting knives and the hydraulic drive system. When moving, the platform is supported by two wheels, and in the stationary position, a support leg on the platform is also used. The platform is coupled to the tractor by means of a tow hitch.
The knife 1 (pos. 2), is mounted on the back of the platform and cuts the stalks at a height of 100 mm from the ground in the working position. In the transport position, the knife folds and rises vertically by using two hydraulic cylinders (see figure 2). The knife 1 is a subassembly that constitutes

the cutting machine and is of the double-knife type, in which the role of the fingers and the counter-cutting plates is fulfilled by the second knife which moves at an equal speed and in the opposite direction with the first.
Knife 2 (pos. 3), is mounted horizontally offset to the first, in the front of the platform and performs cutting of hemp plants' inflorescence. Since the height of the hemp varieties' inflorescences varies, this knife has the possibility to adjust the cutting height in a wide range of values with the help of a vertical cylinder. The second hydraulic cylinder works at the ends of the travel in the working or transport position of the equipment. In transport this knife can be folded 90 degrees backwards on a support, with the help of the hydraulic system (fig.1, pos. 4). This knife is a double-knife cutting machine like the first knife. Each knife is moved by a hydraulic motor through a distributor, operated from the hydraulic system of the equipment (see figure 2).

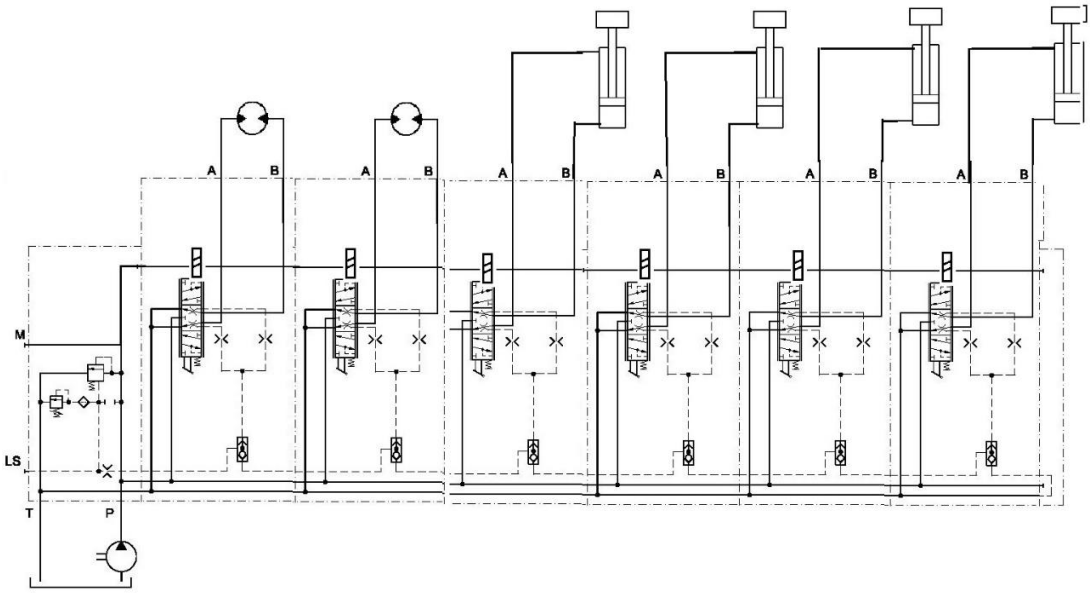

Fig. 2. Hydraulic scheme of the Equipment for harvesting green hemp stalks ERCV-0

The hydraulic system (fig. 1, pos. 4), ensures the independent functioning of the two knives in operation and comprises: a hydraulic motor driven by the tractor, a hydraulic pump, a reservoir for hydraulic oil and connecting elements. The two knives are operated from the tractor cabin.

3. Results

Table 1: General technical characteristics of ERCV-0

Characteristic	Value
Machine type	trailed
Energy source	65 HP tractor
Type of cutting machine	Double-knife
Cutting height: -rear cutting machine -front cutting machine	 100 mm 1500-2500 mm

During the work, the following forces action the cutting machine's knife: the resistance to cutting the plants, the force of inertia and the friction force that appears between the knife and the fixed parts of the machine.

Applying the principle of work conservation, results the resistance R_t **,** [N] to plant cutting on space x_t as formula (1) [8]*:*

$$R_t = \frac{\mathrm{Bh_a\, L_t}}{\mathrm{x_t}} \quad 1)$$

where: *B* - the working width of the knife, in m;
h_a - supply space, in m;
L_t - the work required for cutting the plants on a surface unit, in Nm/m^2.

The force of inertia F_t, [N] that appears due to the alternative translational motion of the knife is calculated with formula (2):

$$F_t = ma \quad (2)$$

where: *m*- knife mass, in kg;
a – knife acceleration, in m/s^2.
The acceleration *a* has the maximum value in the dead points, respectively, the maximum value of the force of inertia, F_i, [N] will be:

$$F_{i_{max}} = m\omega^2\gamma \quad (3)$$

At the half stroke, the acceleration is zero; at this point, the force of inertia is also zero.
The friction force F_f, [N], that appears between the knife and the fixed parts of the machine is calculated with formula (4):

$$F_f = \mu G = \mu B g_0 \quad (4)$$

where: *μ*–the coefficient of friction between the fixed parts of the machine;
G – knife weight, in N;
B – the working width of the knife, in m;
g_0 – linear weight of the knife; g_0 = 20 – 25N/m.
The power P_{at} required to operate the knife of the cutting machine can be determined approximately by the formula (5) [8]:

$$P_{at} = BP_0 \quad (5)$$

where: P_0 – specific power, in kw/m;

Following the specific adjustments of the culture, variety and stage of development, the Equipment for harvesting green hemp stalks ERCV-0 performs the fractional cutting of the stalks as follows:
- rendering uniform the length of the stalks by removing the inflorescence with the upper cutting machine (fig. 1 pos. 3);
- effective cutting of the useful stalks with the lower cutting machine (fig. 1, pos. 2) and leaving them organized on the ground for a period necessary to change colour.

4. Conclusions

Knowing the importance of each characteristic of hemp stalks allows estimating, to a large extent, according to the external appearance of the stalks, their mode of behaviour in the technological process of primary processing, as well as after the probable results of the processing, both quantitatively and qualitatively.
The Equipment for harvesting green hemp stalksERCV-0 is hydraulically operated trailed equipment and is intended for the fractional harvesting of green hemp stalks on small and medium-sized farms, for their further processing.
The main advantages of *ERCV-0 are:*
- low cost exploitation, being recommended for industrial hemp crops on small surfaces;
- simple construction and easy to maintain;

- during operation, the cutting height of the knives can be controlled from the tractor cabin according to the size of the harvested hemp crop;
- during transport the two knives can be folded.

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References

[1] Carus, M., S. Karst, and A. Kauffmann. *The European Hemp Industry: Cultivation, Processing and Applications for Fibres, Shives and Seeds.* Cologne: EIHA, pp. 1–9, 2013.
[2] Amaducci, S., A. Zatta, F. Pelatti, and G. Venturi. “Influence of agronomic factors on yield and quality of hemp (Cannabis sativa L.) fibre and implication for an innovative production system.” *Field Crops Res.* 107 (2008): 161–169.
[3] Struik, P.C., X. Yin, C. Thouminot, M. Bjelková, V. Stramkale, et al. “Comparing hemp (Cannabis sativa L.) cultivars for dual-purpose production under contrasting environments.” *Ind. Crops Prod.* 87 (2016): 33–44.
[4] Ranalli, P., and G. Venturi. “Hemp as a raw material for industrial applications.” *Euphytica* 140 (2004): 1–6.
[5] Sheychenko, V., I. Marynchenko, I. Dudnikov, and M. Korchak. “Development of technology for the hemp stalks preparation.” *Independent journal of management & production* (2019): 687-701.
[6] Salentijn, E.M.J., J. Petit, and L.M. Trindade. “The Complex Interactions between Flowering Behaviour and Fibre Quality in hemp.” *Frontiers in plant science* 10 (2019): 613.
[7] Păun, Anişoara, Gabriel Bogdanof, Ioan Ganea-Christu, Radu Ciupercă, and Mihai Matache. Patent application no. A-00426/04.07.2019 *Equipment for harvesting green hemp / Echipament de recoltat cânepă verde*. OSIM, Romania, 2019.
[8] Neculăiasa, V., and I. Dănilă. *Working processes and agricultural machines for harvesting/Procese de lucru şi maşini agricole de recoltat*. A92 Publishing House, Iaşi, 1995.