CONSIDERATIONS ON THE PROCESSES OF HARVESTING AND PRIMARY PROCESSING OF GREEN HEMP STALKS

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ABSTRACT

Hemp (Canabis 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. 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. Coming to their support, the article presents aspects related to the optimal conditions for harvesting hemp stalks for processing and to establish the main characteristics of the cutting devices of the harvesting machines. The paper presents the Equipment for harvesting green hemp stalks, equipment that performs sequential harvesting of hemp stalks leaving them organised on the ground. At the same time, the technological scheme for harvesting green hemp stalks and its advantages are presented.

INTRODUCTION

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 (Canabis 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. 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.[2,4,7,8, 9,10]

The fibre content in the stalks is influenced by the variety, by the technological and pedoclimatic conditions. Fibres have a number of properties that are particularly valuable as (traction, torsion, friction, rot) resistance, extensibility (elastic and plastic), spinning capacity. [1,3,5,6] The article presents the technology for harvesting green hemp with the equipment related to each operation. This technology will be the basis for the conception, realization and experimentation by the specialists from INMA of high performance harvesting

equipment for green hemp, at a low price, as required by many farmers who grow hemp crop.

MATERIAL AND METHODS

Hemp, Canabis sativa L., figure 1 is an annual plant, with a vegetation period of 120-150 days in seed crops and 110-125 days in fibre crops (harvested at industrial maturity).

The stalk, the component part that constitutes the object of the harvesting technology presented in this article, 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. In the case of hemp, the stalks with the greatest useful length, not branched and thinner, are considered to be the most valuable. They have the highest fibre content, a high fibre yield, and the obtained fibre is more resistant. The colour is also one of the basic characteristics according to which we can appreciate the quality of the stalks. It indicates: the degree of maturity at which the harvest was made, the drying and storage conditions, the attack of certain diseases.

The quantity and especially the resistance of the fibres can be appreciated also by the mechanical characteristics of the stalks, respectively by their resistance to breaking. 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 quality of the stalks is better, the higher their tensile strength. This feature can be determined by laboratory analysis, by breaking it using a dynamometer.

In our country, the physical characteristics underlying the classification by commercial qualities and by technological groups of hemp stalks are according to table no. 1.

Table 1

Qualitative classification of hemp stalks

Quality class	I	II	III	IV
Colour	–Yellow, greenish-yellow in the case of at least 90% of the stalk mass –No turned black stalks	–Yellow, greenish-yellow in the case of at least 80% of the stalk mass –No turned black stalks	–Yellow, greenish-yellow in the case of at least 75% of the stalk mass –Turned black stalks, max. 5% of the stalk mass	–Yellow, greenish-yellow in the case of at least 60% of the stalk mass –Turned black stalks, max. 10% of the stalk mass
Useful length: – in the case of at least 80% of the stalk mass, cm – at the rest of the stalks, cm	 min.150 min.130	 min.130 min.100	 min.100 min.70	 min.70 min.50
Average thickness of the stalks, mm	max.6	max.8	max.10	max.12
Stalks attacked by pests or damaged by hail, deformed,%	max.3	max.7	max.12	max.15
Moisture,%	max.14	max.14	max.14	max.14

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. Production management is different for an exclusive fibre production. The seed set is not important and should be avoided. When the seed set appears, cellulose and pectin levels accumulate in the stalk, which makes separation of wild fibres and shells more difficult. 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. Within the fibre crops, the harvesting process comprises the following operations according to figure 1.

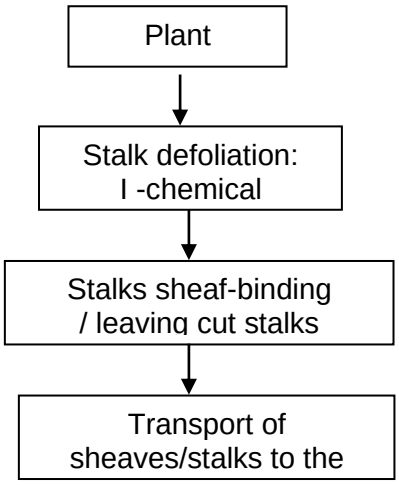

Figure 1. Operations of the harvesting process

Defoliation can be done before cutting the plants, by using chemicals or, after the plants have been cut, mechanically, by shaking and striking. It can be said that chemical defoliation can have a negative influence, manifested by the partial degradation of a quantity of the treated fibres or it can have negative ecological implications, if the applied substances are considered polluting.

In general, in Romania, the second variant is practiced, namely the defoliation by mechanical actions, respectively, after the stalks had been cut, they are left in strips on the stubble field, for the leaves to dry, then they are taken from the ground, the leaves and the stalks are shaken, sheaf bound, loaded and transported to the primary processing stations. Harvesting hemp for fibre is done at the end of flowering, when the stalks have become golden-yellow.

Figure 2 shows the technology for harvesting green hemp with the equipment related to each operation; it can be observed that depending on the use of green hemp there are several harvesting options.

RESEARCH RESULTS

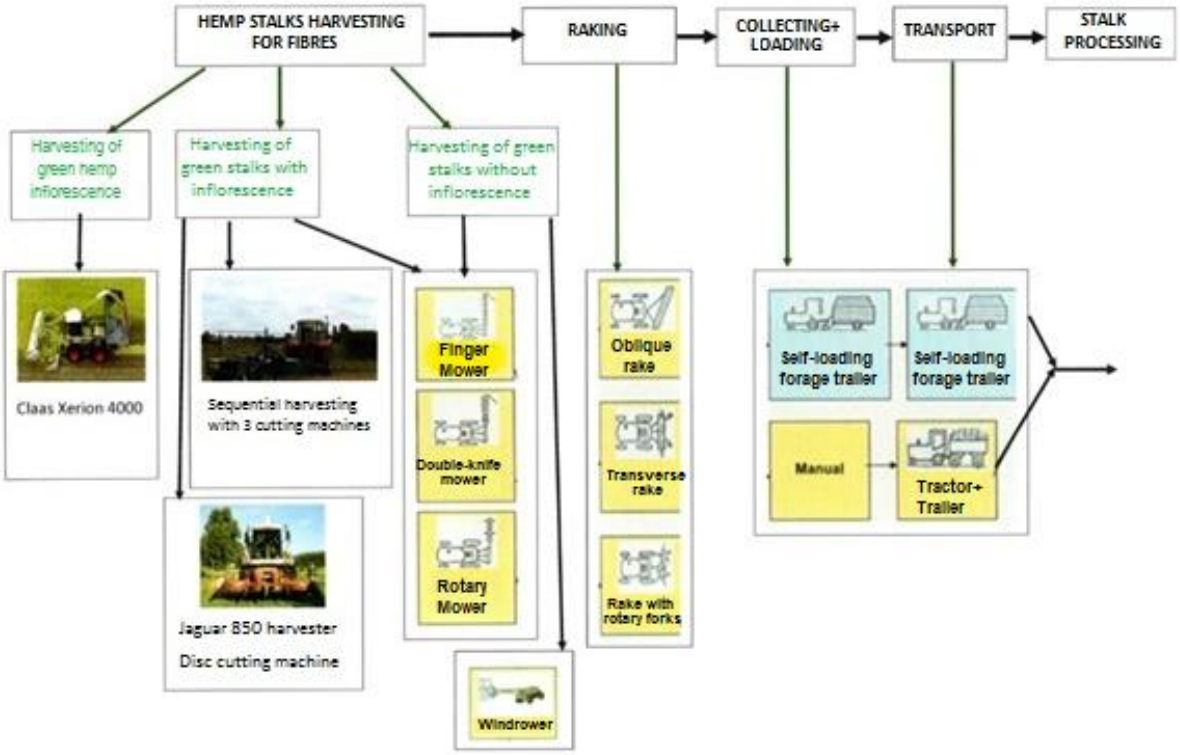

Figure 2. Technology for green hemp harvesting

If we want to use the green inflorescence, technical equipment mounted on a high power tractor can be used for harvesting it. With the help of this equipment at a single pass, the inflorescence is harvested, which is taken over by two belt conveyors after being cut, unloaded in a trailer suspended on the tractor and the stalks are cut and left organised on the ground.

In case of harvesting the whole plant, the following can be used: technical equipment with 3 cutting devices (sequential cutting), harvester with disc cutting machine, finger mowers, double knife mowers, rotary mowers, windrower.

According to figure 2 when harvesting green hemp without inflorescence you can use: finger mowers, double knife mowers, rotary mowers, windrower. The cutting machines of the combine harvesters are the main parts that influence the cutting process; they perform the separation of the plant parts by shearing - the cutting part (knife) acting on the plant with a speed of 1-2.5m/s. During cutting the plant is supported by a counter-cutting part, usually fixed. The most common cutting machines used in combines, figure 4, are those in which the knife has a rectilinear movement, with a counter-cutting, fixed part (classical construction devices). In some combines, the fingers are not provided with counter-cutting plates, their role being fulfilled by the edges of the finger body themselves. The movable part of the cutting machine is represented by the knife itself - that is, formed by the bar on which the cutting blades are mounted. The cutting blades have sharp cutting edges at an angle of 19-23˚ and they can be smooth or toothed; the teeth can be made either on the top or on the bottom part.

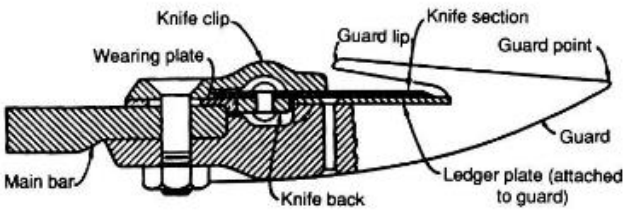

Figure 3. Constructive scheme of the cutting machine

Finger cutters used at harvesting machines (mowers, reapers, combines) are of three types: normal cutting, average cutting and low cutting. Cutting machines can have single or double knife stroke.

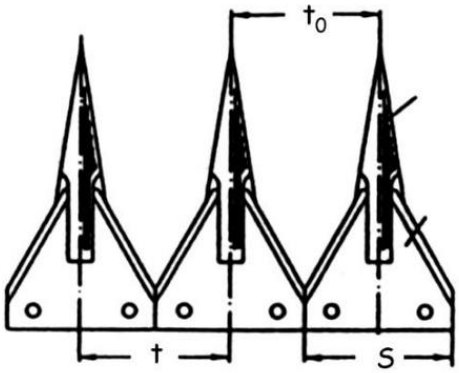

Figure 4. Characteristics of shear cutting machines

The simple stroke of the cutting machine's knife represented in figure4 is determined by the relation [4]:

$$S = t = t_0 = 76.2 \text{ , mm} \quad (1)$$

where: *S* is the knife stroke at the half-turn of the crank, mm;

t – the distance between the axes of two blades (step of the blades),mm;

t_0–the distance between the axes of two fingers (step of the fingers), mm.

The process of cutting the plants by the cutting machine is carried out in 3 stages:

a) inclining the stalks by the cutting edges of the knife blades in the direction of their movement;

b) compressing the stalks between the edges of the blades and of the counter-cutting plates;

c) cutting the compressed stalks.

The inclination of the stalks by the cutting edges of the blades occurs without sliding if the angle between the tangent to the blade trajectory and the normal to the knife edge does not exceed the angle of plants friction on the blade edge.

The inclination of the stalks by the blade ceases when they reach the edge of the finger's counter-cutting plate. From this moment begins the compression of the stalks that entered the space between the blade and the finger during a knife stroke.

In the compression process it is possible for the stalks to slide out, if the angle between the edges of the cutting blade and of the counter-cutting plate will be greater than the sum of the angles ($\varphi + \varphi_1$) of plant friction on these edges.

The critical angle, which ensures the maintenance of the plants between the edges of the cutting coupling, is given by the relation:

$$\psi_{cr} \leq \Sigma(\varphi + \varphi_1) \quad (2)$$

This angle may have values depending on the state of the blade edge and of the counter-cutting plate, as well as on the humidity of the plants. By properly choosing the dimensions of the cutting couplings, it is possible to cut the plants without sliding or with sliding. The size of embedding in the case of smooth edge knives depends on the sharpness of the blade edge and of the counter-cutting plate. The sharp edge, in contact with the stalk, makes a cut, and further sliding of the stalk along the edge is hampered by the cutting edge entering the plant stalk and by friction force increase. When the blade turns blunt, the small teeth that form when sharpening disappear and the friction coefficient decreases. A good cutting of the plants is obtained if the cutting thickness does not exceed 80 - 100 μ and the angle of attachment will be:

$\psi_{cr} < 22^{\circ}$ for cutting blades and counter-cutting plates

and

$\psi_{cr} < 30^{\circ}$ for smooth cutting blades and toothed counter-cutting plates

During the work, the following forces act on 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 to plant cutting on space x_t:

$$R_t = \frac{B h_a L_t}{x_t}, \text{ N} \quad (3)$$

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 inertiaF_t that appears due to the alternative translational motion of the knife is:

$$F_t = ma, \text{ N} \quad (4)$$

where: m- knife mass, in kg;

a – knife acceleration, in m/s^2.

The acceleration a has the maximum value in the dead points, when φ = 0 or $\varphi = \pi$. Respectively, the maximum value of the force of inertia will be:

$$F_{i_{max}} = m\omega^2\gamma \quad (5)$$

At the half stroke, the acceleration is zero; at this point, the force of inertia is also zero.

The friction force F_f that appears between the knife and the fixed parts of the machine:

$$F_f = \mu G = \mu B g_0 \quad (6)$$

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 relation:

$$P_{at} = BP_0, \text{ Kw} \quad (7)$$

where: P_0– specific power,in kw/m

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.

According to those analysed, when making the technical equipment for harvesting green hemp stalks, the following technological requirements must be taken into account in case of harvesting the hemp for fibre: the average

cutting height from the ground should not exceed 7 cm, the stalk losses should be less than 5% and the percentage of broken stalks should be no more than 6%.

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