INFLUENCE OF BIO-PREPARATION ON CUTTING CHARACTERISTICS OF CANNABIS RESIDUES

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Abstract. The aim of this work is to determine the influence of bio-preparation for cutting mechanical characteristics of cannabis plant residues, depending on the biological preparation action period and compare the research results with the same researches obtained in natural conditions. The influence of bio-preparation on cannabis residues cutting with different knives was determined. Experimental research in the physical-mechanical properties of plant residues was conducted at the Institute of Agricultural Engineering and Safety of Aleksandras Stulginskis University, using the experimental research machine "Instron 5960". The results of the experimental research showed that the forces required for cutting of cannabis plant residues are lower using biological preparation than without it. Using an angled knife for cannabis residues cutting left on the soil surface less force is needed than using a vertical knife. Summarising it can be asserted that many factors such as the type of the plant, the time lying on the soil, biological preparation and its action period, constructional parameters of the cutting knives and other factors influence the mechanical characteristics of plant residues cutting forces.

Keywords: cannabis residues, bio-preparation, cutting.

Introduction

Hemp (Cannabis sativa) as an annual plant is valued for its grown because of fiber, seeds and the quantity of high cellulose in the stems. Lately Europe is characterized by rapid expanding possibilities to use cannabis products: from previously used to produce textiles, technical products (rope, string, nets, tarpaulins, upholstery, tow) to now for ethanol and paper producing [1; 2]. Using all parts of cannabis plant from 25 000 to 50 000 different products can be manufactured. Thus, the Republic of Lithuania law on hemp for fiber cultivation [3] promotes and provides a significant opportunity to improve diversification in Lithuania agriculture [4]. From cannabis in Lithuania oil, candy, spices, bakery products (bread, crackers), pizza, vodka, beer, wash, scrub, grease joints and building blocks are produced.

Through researches of mechanical characterization of cannabis residues, when humidity of cannabis is high, we can say the following – through cutting the stem separates from the fiber in the chaff form, but mature stems are often hollow and can be crushed.

Decomposition of plant residues in the soil takes place by microorganism (retting fungi or bacteria) digestion of cell bundles of cannabis fiber (cellulose, hemicellulose, pectins, lignins) [5], in order to speed up the decomposition processes we can affect cannabis residues biologically.

Biological preparations are used as a soil and plant food substance. Plants sprayed with a solution of this preparation absorb mineral substances better, intensively grow and affect splant productivity increasing [5]. Biological preparation contains progenitor nitrogen fixing bacteria and biologically active substances that act on the structure of plant residues, activate mineralization of the soil surface and accelerate the decomposition of plant residues and the weakening processes of mechanical properties [6; 7].

The fiber is strongly woody at stems of hemp, near the roots, so it is particularly important to process cannabis stubble with biological preparation. It is necessary to use higher cutting force, plants accumulate more lignin, reduce the elasticity, complicate plant residue cultivation when plants are older.

The required force for cutting and the strength of cannabis residues (quantity of fiber stems) are influenced by the factors as cannabis variety, soil, meteorological conditions (light, temperature, humidity), nutrient content, fertilization, sowing time and density, harvesting time (growing agro-technology), stem thickness knots and [8-10].

German scientists argue that cannabis yields are highly dependent on meteorological conditions, soil and less on the variety, fertilization and sowing time [11]. The working part construction and

technological parameters have great importance for cutting and termination of plant residues [12; 13]. Humidity affects the need of cutting power [9; 10; 12; 14].

Summing up the studies carried out by various scientists, biological treatment of plant residues affect not only the plant productivity but also its physical - mechanical properties. The aim of this work was to investigate mechanical characteristics of hemp, which were affected by biological preparation in different time periods using different construction cutting knives.

Materials and methods

Experimental research of physical-mechanical characteristics of cannabis residues was carried out in 2014 at the laboratory of the Institute of Agricultural Engineering and Safety of Aleksandras Stulginskis University. Mechanical characteristics of cannabis residues sampling were determined from LAMMc Upytė experiment station after harvest from uncultivated soil. Samples of cannabis residues were weighed (accurate to 0.01 g) and dried to air-dry mass in the drying oven at 105 ºC. Humidity of cannabis residues was calculated according to the obtained results of the sample mass. Then we assessed the changes depending on the duration of plant residues storage. Every time in determining of plant residues dry matter content were carried out 5 reps.

At the beginning was carried out investigations in the initial mechanical characteristics of plant residues. After that every plant residue was divided in two parts and spread on the surface of uncultivated soil. One of each parts of both plants was left on the soil surface under natural climatic conditions. Another part of plant residues was artificially sprayed with biological preparation, with the spraying rate of 1.0 $l \cdot ha^{-1}$, preparing the solution with water in the ratio 1: 200.

Cannabis residues were treated with one of the most popular and mostly investigated biopreparation consisting of nitrogen-fixing bacteria *Azotobactervinelandii* $1 \cdot 10^9$ ml \ 5 %. hard materials, 4.5 %. Humic acids, 0.5 %. Gibberellic acid, 0.01 %. copper (Cu) 0.01 %. zinc (Zn) 0.01 %. manganese (Mn) 0.01 %. iron (Fe), 0.01 %. calcium (Ca), 0.005 %. sodium molybdate (Na_2Mo0_4) [15].

Through the research of mechanical characteristics of cannabis residues we seeked to establish the effectiveness of biopreparations by the resistance trend of cannabis residues cutting stems.

Experimental researches were done in 8 weeks period, during which one time in every 14 days the biological impact of plant residues cutting mechanical characteristics was determined. The received characteristics were compared with not affected properties of plant residues in natural climatic conditions. It is difficult to maintain the same humidity of different plant residues in natural climatic conditions, so during each mechanical characteristics research humidity of plant residues was repeatedly determined.

While the mechanical characterization measurements were simulated mainly disc coulters with trimmed blade were used that can better cut plant residues than the level blade disc coulters [16; 17], and their exploitation contributes to solve tillage and sowing machine problem of coulter clogging in the soil which is coated with plant residues [19-21]. So, the cutting tests of plant residues have been performed with two different knives, which imitated the disk coulter. Researches of cutting mechanical properties of plant residues were performed in the experimental research device “Instron 5960” for especially small forcing measurements (Fig. 1). This devise measures the plant residue cutting force and the established values were transferred to the computer and processed with the Bluehill program.

To ensure natural conditions of cutting, the experimental researces of plant residues were carried out in interaction with the soil. Both knives blades were sharpened up to 30º angle. The tests were carried out with light loam soil which humidity was 10 ± 2 %, and toughness – about 1 ± 0.2 MPa, corresponding to minimum tillage conditions. One vertically swooping knife cut plant residues perpendicularly to the surface of the soil, in the same way as the equal blade disc coulter blades do. And the other angle of the knife constructed 62º (Fig. 1. 6B) simulating plant residues cutting in the disc coulter blade notch. In this way the sliding cutting process of plant residues was obtained. Through the research the movement speed of the knife was 50 $mm \cdot min^{-1}$. In order to ensure equal physical properties of soil and experimental research conditions, after each test of plant residues

cutting the soil was re-compacted and its surface hardness and humidity measured using the Eijkelkamp company device penetrologger.

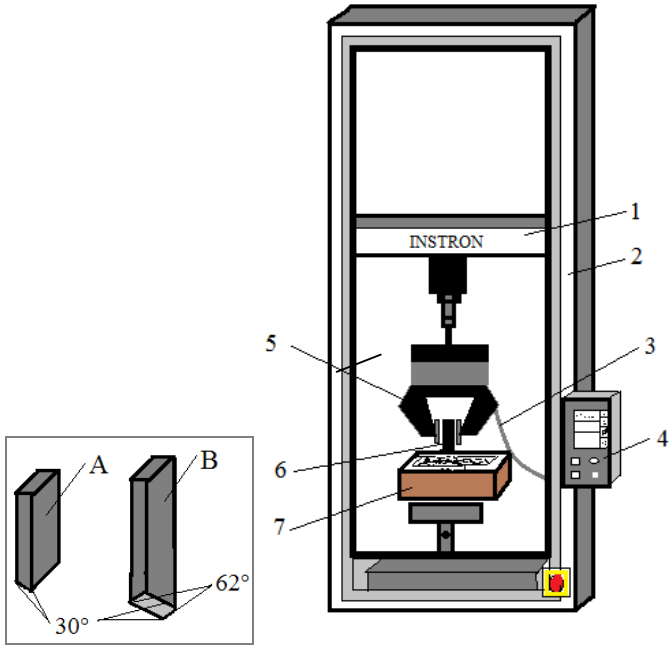

Fig. 1. **Mechanical characteristics research device "Instron 5960":** 1 – upper stroller; 2 – frame; 3 – tube of air supply to grabs; 4 – Control Panel; 5 – grabs of plant residues; 6 – knife (A – knife swooping vertically down, B – angled knife); 7 – box with the soil

Both affected and not affected with biological preparation cannabis residues cutting researches were carried out in 5 replications. The obtained data of the experimental researches were processed by mathematical-statistical methods at 95 % probability level [22].

Results and discussion

In order to reduce soil tillage machine fuel and energy costs, while reducing environmental air pollution, it is particularly important to facilitate tillage of plant residues. The force required for plant residues cutting is a very important technological indicator, which shows how machines could cut cannabis residues. Therefore, through further researches the effectiveness of using biological preparations by cutting cannabis residues with swooping vertically and angled knife was assessed, in conjunction assessing the influence of the storage time, humidity, swooping blade depth.

The humidity of control and biologically treated cannabis residues during the whole period was an average of 30.27 % – control and 31.89 % – sprayed biopreparations (Table 1).

Since the previous research [23] it was found that increasing the swooping depth of the knife influences higher amount of cutting straw, so through experimental research the swooping depth of the knife was evaluated (Fig. 2) and the results contain cutting power dependence on the swooping depth of the knife into the soil. In experimental researches different knife cutting forces depending on the swooping depth of the knife cutting only soil were additionally evaluated (Fig. 2). In order to show an average up to 100 N differences of the cutting force values and the scattering about the overall average values obtained in all tests (Fig. 2), an average of three different tests using different cutting blades was approved.

During the regression analysis, the estimated cutting force retries the test average values connection precision. When calculating the coefficient of determination, it was established which variation cutting force part of values countertops the dependence model. So, graphical presentation of the measurement data visually indicate that there is the cutting force average value spatial distribution tendency. Most values of the cutting force when the cutting angled knife and the cutting vertical swooping knife changed linearly showed a diverse variation of values (by a polynomial dependence, etc.).

Table 1

Biopreparations, cutting method and storage time influence on medium cutting characteristics of cannabis residues, humidity, knife swooping depth

Storage time	Cutting method	Treatment	Humidity. %	Medium cutting force. N	Knife swooping depth. mm
The beginning of researches	Swooping vertically knife	Unaffected with biopreparation	53.72	711.274	47.76
	Angled knife		53.72	102.34	52.01
After 14 d.	Swooping vertically knife	Affected with biopreparation	21.53	510.14	57.36
	Angled knife		21.53	89.54	54.21
	Swooping vertically knife	Unaffected with biopreparation	18.57	526.02	56.63
	Angled knife		18.57	95.21	55.20
After 28 d.	Swooping vertically knife	Affected with biopreparation	25.11	345.56	53.06
	Angled knife		23.89	68.41	52.48
	Swooping vertically knife	Unaffected with biopreparation	22.44	445.09	54.95
	Angled knife		21.78	72.11	50.57
After 42 d.	Swooping vertically knife	Affected with biopreparation	49.07	209.60	49.28
	Angled knife		49.07	45.38	50.69
	Swooping vertically knife	Unaffected with biopreparation	26.34	294.86	52.40
	Angled knife		26.34	65.53	53.20

In view of the results in Fig. 2 and evaluating the influence of the swooping knife depth on the cutting force values not fully equivalent increase of the cutting force when cutting by the verticaly swooping knife and an average variable range from 0 to 550 N were determined. It can be argued that the knife swooping till an average of 37 mm caused significant changes of the cutting force, and from 37 mm with a steep increase of the cutting force through 1 cutting with the vertical swooping knife and at an angle knife through 3 trials. In summary, a clear difference was established, because the cutting force using the angle swooping knife is needed to an average 2.5 times less than using the vertical swooping knife when the knife sinks into the soil up to 40 mm.

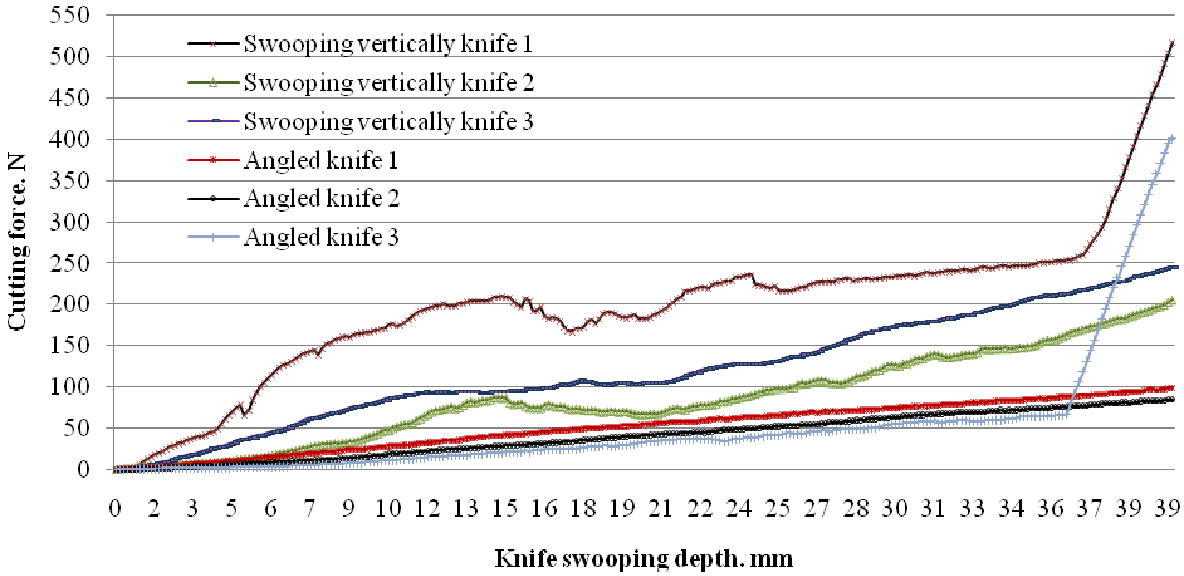

Fig. 2. **Cutting force dependence on different knives swooping depth cutting only the soil**

The experiments showed that for both cannabis residues stored in natural climatic conditions, as well as affected with biopreparations the mechanical cutting characteristics weakened in the whole period. A longer storage period influenced cannabis residues stem decomposition processes – the cutting characteristics weakened (Fig. 3).

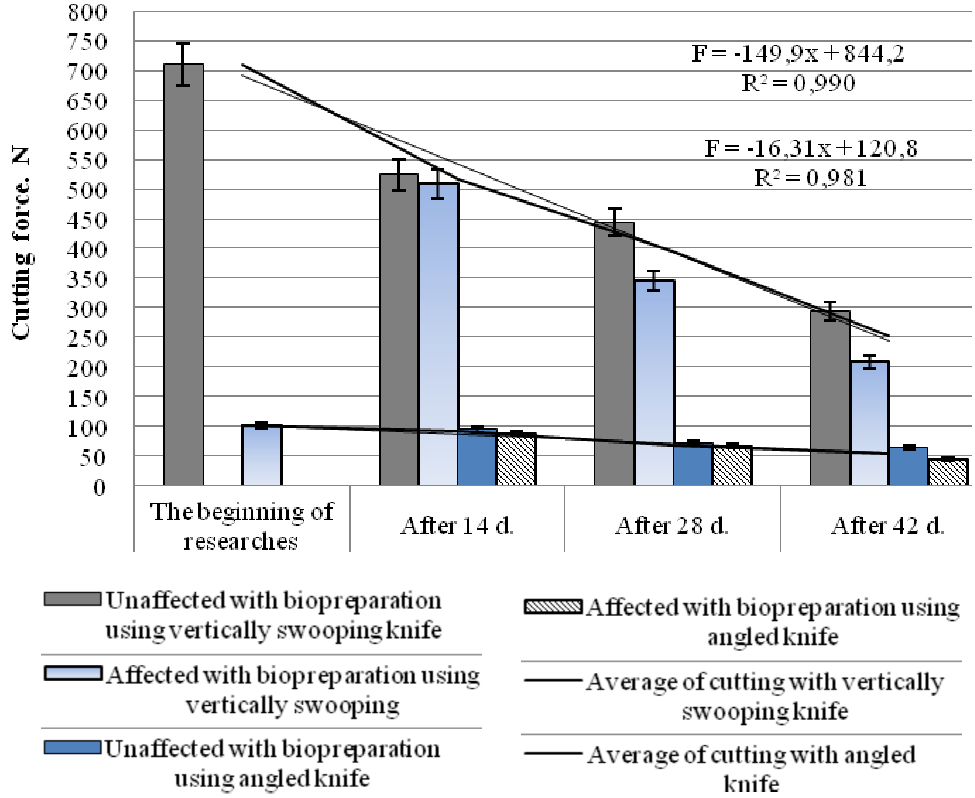

Fig. 3. **Cutting force using vertical swooping and angled knives dependence on biopreparation treated cannabis residues storage duration in natural conditions**

Assessment of the biopreparation using influence on cannabis residues cutting showed that after 4 and 6 research weeks using the vertical swooping knife there are the biggest differences between naturally stored and sprayed with biological preparation cannabis residues – an average from 85 to 100 N. Respectively, using the angled knife, the maximum effectiveness of biopreparation was after 42 days of the research – whopping 32 %. In all researche periods cannabis residues affected with biological preparation required the cutting force that was slightly less than for the control cannabis residues. The average standard deviation 43.49 N and the coefficient of variation – 0.154 % was obtained by calculating the average of all cutting forces of cannabis residues. Low coefficient of variation indicates a lower average required cutting force.

In order to identify more factors, which influence the cutting force of cannabis residues in contact with the soil, Fig. 4 shows all tested factor changes and dependence cutting with the vertical swooping knife.

The required average cutting force when cutting cannabis residues without additives was higher in all recorded periods. The biggest differences are set when the residues of cannabis storage duration was the greatest in natural conditions.

If cannabis residues are stored on the soil surface for a longer time period, higher humidity was estimated, and the required cutting force decreasing. So, this change tendency could be the reason of the cutting force reduction.

Assessing the average of the depth of the swooping knife when cutting progressively longer maintained cannabis residues, it was found that the change of control and biologically treated cannabis residues decreased slightly in both cannabis variations, but the lowest values were observed in cannabis residues treated by biopreparations. Most of the factor variations that may affect the cutting force were smooth and high dispersal among average values was not observed.

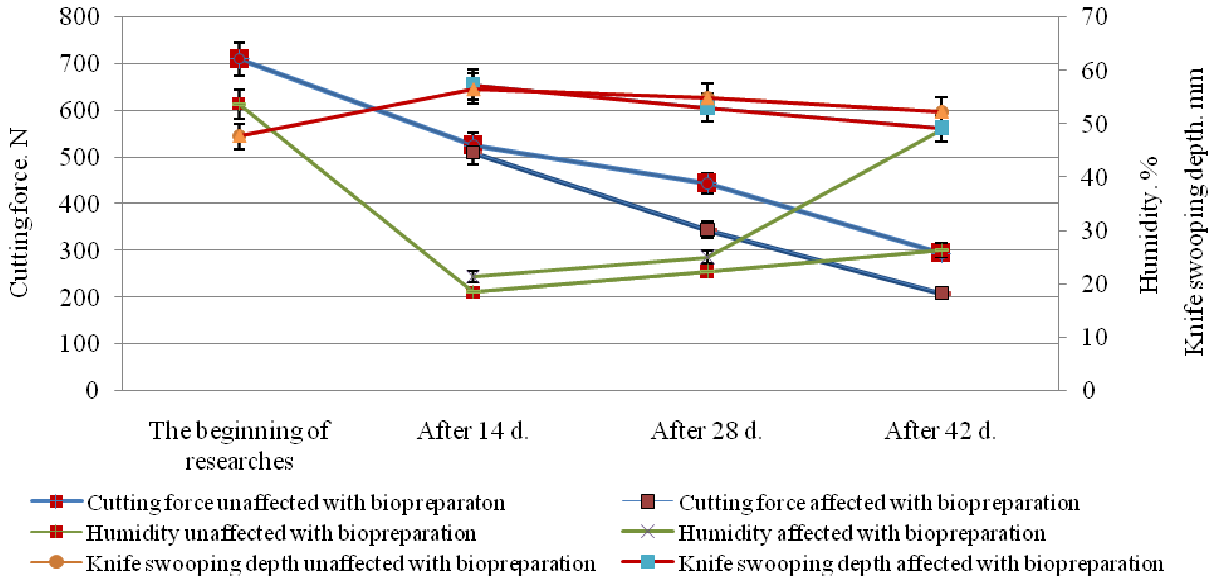

Fig. 4. **Cutting force using vertical swooping knifedependence onstorage time, knife swooping depth, humidity of cannabis residues treated by biopreparation**

In summary, the research in cannabis residues cutting has shown that the cutting force is greatly dependent on the technological process of cutting. The results obtained using the vertical swooping knife and cutting with the angled knife were different. Significantly better results were obtained by cutting with the angled knife and biologicaly treating cannabis residues, which proves the benefit of the sliding cutting process and usage of biopreparations for improving cannabis residues cultivation after harvesting and for reducing harvesting machine energy and fuel consumption.

Conclusions

1. The use of biological preparation accelerates hemp residues remaining after harvest decay processes and influence the mechanical characteristics of the treated biological preparation of cannabis residues. The researches have shown smaller required force for biologically treated hemp residues cutting than the force required to control. Longer storage period of cannabis residues influenced the residues stem decomposition processes.
2. Evaluating the depth of the swooping knife influence on the cutting force by cutting only the soil there was markedly the cutting force difference – an average 2.5 times lower cutting force using the angled knife than by cutting with the vertical swooping knife, when the swooping depth is up to 40 mm.
3. The research evidence has shown that after 4 and 6 research weeks cutting with the vertical swooping knife established the bigest differences between naturally stored and sprayed with biopreparation cannabis residues – an average from 85 to 100 N, and using the angled knife, after 42 research days – even 32 percent.

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