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PREPARATION FEATURES OF TECHNICAL MEANS FOR HAYMAKING**Oleksandr Kholodiuk**, Candidate of Technical Sciences, Senior teacher

Vinnytsia National Agrarian University, Vinnytsia

Volodymyr Kuzmenko, Candidate of Technical Sciences, Senior Research Fellow,

Institute of Mechanization and Electrification of Agriculture

Zhukov Volodymyr, Candidate of Agricultural Sciences, Senior Research Fellow,

Institute of Feed Research and Agriculture of Podillya NAAS

Холодюк Олександр Володимирович, к.т.н., старший викладач

Вінницький національний аграрний університет

Кузьменко Володимир Федорович, к.т.н., старший науковий співробітник

Інститут механізації та електрифікації сільського господарства

Жуков Володимир Павлович, к.с.-г.н., старший науковий співробітник

Інститут кормів та сільського господарства Поділля НААН

Increasing production of livestock products requires a radical improvement of fodder production on farms and, above all, the procurement of stem fodder as such, ensuring the completeness of cattle feeding. Modern technologies and technical means of forage harvesting allow to perform high-quality work in agro-technical terms.

It is noted that haymaking, as well as other fodder, provides a systematic, comprehensive approach to the organization of work, staffing a set of technical means, their preparation for work, the collection and subsequent storage of feed.

The purpose of the research is to substantiate the peculiarities of the preparation of technical means for the procurement of leaf and stem materials for hay for the current state of technology in Ukraine and the world.

In the scientific work the peculiarities of preparation of technical means for harvesting hay from legumes and legume-cereal mixtures are considered. It is noted that to obtain high-quality hay should be widely used technical means that accelerate the drying of grass in the field: conditioners, tedders, rakes, and for drying hay - ventilation systems with heated air. The basic measures, adjustment and preparation of mechanization means at mowing, flattening, agitation and harvesting of hay are substantiated.

It is noted in the work that increasing the compression force of the rollers of the mower E-303 helps to accelerate the drying of the roller mass of the clover. It is established that the use of roller mower conditioner allows to get the weight for hay 2-3 days after mowing, which is less per day than mowing without weight conditioning. The obtained results allow to recommend the installation of rollers with an edge in front of the edge for accelerated drying of the mass, which allows to accelerate the drying process by 9-12 hours.

Key words: fodder stem, fodder preparation, hay, drying, mowing, flattening, agitation, rake, baler, pick-up truck.

F. 1. Fig. 7. Ref. 9

1. Introduction

Increasing production of livestock products requires a radical improvement of fodder production on farms and, above all, the procurement of stem fodder as such, ensuring the completeness of cattle feeding. Production of high-quality fodder stems requires strict compliance with agro-technical requirements for harvesting times while minimizing specific material and technical costs, optimizing the composition of forage harvester complexes, using modern technical means, such as mower-conditioners (air conditioners), which can significantly accelerate the moisture transfer of cut grass.

The state of stockbreeding significantly depends on the competitiveness of its products, which is influenced by highly productive animal breeds, modern energy and resource-saving technologies for their maintenance, appropriate facilities and modern mechanization for the implementation of these technologies. The technical means used indirectly affect the energy and resource consumption through the consumption of fuels and lubricants and consumables. However, one of the most important factors shaping the competitiveness of livestock products is feed, because they account for up to 60% of milk costs, for example, in dairy farming [1]. Along with concentrated feeds and supplements an important place in the diet belongs to stem feeds (green



fodder, hay, haylage, silage, canned wet grain), which are produced directly on farms. To obtain high milk yields and ensure the competitiveness of products, these feeds must be of high quality, provide nutrients up to 9.6-10.0 MJ of energy per 1 kg of dry matter, balance the diet with carotene, vitamins and minerals.

2. Analysis of recent research and publications

Modern technologies and technical means of forage harvesting allow to perform high-quality work in agro-technical terms [2, 3, 4]. On the basis of these feeds it is possible to use complete rations, which increase the productivity of animals by 15-20% and due to digestibility and edible feed costs are reduced by 10-15% [5].

Stem fodder produced directly by farms is hay, haylage, corn silage. Technological processes of their procurement are transformed in the direction of ensuring the quality of feed, technical means are improved in order to increase productivity and reduce the energy consumption of the processes.

3. The purpose of research

Substantiation of the preparation features of technical means for harvesting leaf and stem materials for hay for the current state of technology development in Ukraine and the world.

4. Methods of research

Monographic, analytical, systematic analysis of the transformation of technical facilities and technological processes of procurement and storage of stem fodder and prospects for their development.

5. Results of research

Haymaking, like other fodder, involves a systematic, comprehensive approach to the organization of work, staffing a set of technical means, their preparation for work, the collection and subsequent storage of feed.

First of all, the required amount of fodder should be calculated taking into account the stocks, the crops should be determined and the areas for sowing should be provided. The highest quality hay is obtained from legumes and legume-cereal mixtures. It is advisable to harvest hay from less productive second and third mowings, as the protein compounds present in legumes slowly give off water and thus require an additional 1-2 days for guaranteed drying of the first mow.

As harvesting takes a short period of time and already harvested hay can be wetted by precipitation and lose quality, special attention should be paid to the preparation of the canopy or hangar for hay storage, providing the necessary storage space, prepare passages for the loader. The loader for hay storage should be carefully prepared, using the gripper to work in accordance with the condition of the hay (rolls, bales, loose hay), provide lighting for the possibility of work at night.

When planning hay harvesting due to the possibility of not always predicted short-term showers, it should be possible to change the sequence of individual operations without performing some of them under favorable conditions, speeding up or suspending some work, ie the technological process of harvesting should be flexible, ensuring guaranteed obtaining quality feed. It should be understood that procurement operations are performed both in the field and in the production premises. It is in the field that the raw materials are dried and after the completion of field operations the return to the drying process requires increased costs.

Also, when preparing technical means based on the results of last year's season, it is necessary to qualitatively eliminate faults and replace, if necessary, individual parts. For mowers, it is necessary to stock up on knives. It is necessary to have spare rakes for hay tedders and rakes, etc.

When the scope of work is determined, the storage and technical means for harvesting are prepared in accordance with the scope of work, the team for harvesting is formed, it is time for haymaking. The beginning of mowing work on any slope should be done in such a way as to complete mowing: for legumes - at the end of the budding phase, for ear crops - at the beginning of earing. At this point, the herbs have the maximum nutritional value, which maintains at this level for 2-4 days. Over the next four days, a third of the protein is lost in legumes, and 12 % of energy is lost in cereals. Thus, procurement work should last no more than four days. Height of mowing grass should be 8 - 10 cm. Cut is not torn, stubble should not differ in height. Working speed for rotary mowers: 10-12 km/h and more, for segment-finger mowers - up to 7-9 km/h. On rotary mowers it is necessary to control sharpness of knives and if needed to change them on sharpened. Weighted mower beam from one of the edges should come off the ground with a force of 25 - 30 kg. The roll should be uniform, without clusters, straight. Shift start of work should be at 9 - 10 o'clock (obligatory condition - absence of dew), end of work is at 19 o'clock (before dew). In the absence of dew, mowing is possible at night. When monitoring the work, it is necessary to make sure that the mower does not remove dust, does not pick up the turf, and evenly cuts the grass. On the



second slope, the height of mowing should be reduced to 5-8 cm. If foreign objects are found in the field, the work should be immediately stopped and the objects should be removed.

When replacing one mower with another, further increasing their number, one should keep in mind not only the unification of the mowers, but also the prospects for economic development, the ability to perform work on time and efficiently.

In addition to soil contamination of the mown mass, the requirement for mowing is the cleanliness of the cut, the absence of soaking the tips of the stems. This figure is ensured by the sharpness of the blades.

For mowing, mowers with a segmental-finger cutting device, which provide support cutting are used. However, these machines, providing quality mowing, working at speeds up to 7-9 km/h and due to low productivity are used mainly in small farms.

The requirements of productive mowing are met by low-drive rotary mowers of well-known manufacturers: Claas, Kverneland, Kuhn, Krone, Pöttinger, SaMASZ, Sip and others. All of them, due to the high speed of the knives (about 80 m/s) reliably mow different crops at a speed of at least 15 km/h. The basis of the mower is a cutting drive beam, which is connected to the rear hitch of the tractor using the weighing system. There is also a drive system for cutting elements. The width of the mower depends on the length of the beam and varies in the range of 2.1-3.2 m. Most beam structures are collapsible in the horizontal plane. However, the latest designs include welded versions with end caps (Krone).

Elliptical disks in the size of 390... 420 - 200... 300 mm with intercenter distance on axes of disks 370... 420 mm are established on shafts of gear wheels of drive beams. Knives are installed on them. Machine developers create designs that provide reliable, clean mowing. Thus, the drive beams of Claas Disco mowers of different widths are unified and due to the "tunnel" effect that occurs when the mower moves between the recesses on the lower bearing surface of the beam, all dirt is removed there and thus cut stems are not contaminated. Due to the ellipticity of the discs, the knives near the beam form a significant area of overlap, which contributes to reliable mowing. The variable plate installed in this place also promotes the same. Previously flat rectangular knives with pointed ends on the sides were used, but in modern models with the same dimensions of the knife 48 × 120 mm rear in the direction of movement is raised above the front by 5-6 mm, which helps to transport weight and avoid re-cutting.

The design of modern mowers uses an elongated central beam for high-quality weighing of the beam, which is connected to the cutting beam in the center of its weight and maintains a constant pressure on the ground due to the weighing system. This allows not only to keep the turf intact, but also to extend the service life of protective surfaces, reduce fuel consumption by 20 % (at least 1 l/ha), reduce the content of contaminants in the feed by 17 %. The degree of weighing of a bar can be adjusted from a tractor cabin that is important when mowing sites.

To minimize downtime in the event of an accident due to foreign objects being jammed by Claas discs, Krone offers safety devices which, when destroyed, leave the disk and knives in working condition. Replacing damaged parts with new ones takes up to 20 minutes. Also saves time spent on maintenance of the mower of fastening of knives to a disk by means of spring clamps. This significantly reduces the time with constant replacement of knives.

However, the need for high rates of mowing and the use of powerful tractors with a rotary cab (over 200-250 hp) leads to the use of a combination of mowers: rear-mounted right and left and front-mounted front. This combination can be hung on the rear hitch of the tractor (Fig. 1).

*a**b*

Fig. 1. Power tool "XERION 3300" with a combination of mowers DISCO 8600DUO in work (a) and when moving (b) Source: author's proposal

Mowing with a combination of three DISCO 8600DUO rotary mowers in a unit with XERION 3300 power tool in the farm confirmed the mower's productivity per hour of net time of 10.65 ha/h. At the same time, with a construction width of 8.3 m, the width of the capture was 7.84 m. The height of the stubble in normal mowing conditions is 7.88 cm, on fallen alfalfa 18.19 cm. The working speed of the mower is 13.58 km/h.

Immediately after mowing the grass begins the process of drying. As plants dry out, 'starvation' exchange occurs, which is characterized by the predominance of decomposition of organic matter over their synthesis. With long-term 'starvation' exchange losses reach more than 10-15 %. In order to minimize losses, it is important to bring the humidity of the mown grass to less than 35 % as quickly as possible [6]. This can be achieved by conditioning the cut grass.

Due to the mass conditioners, which are rollers and beaters, the protective layer on the surface of plants is destroyed, which protects them from drying out. Simultaneously with the destruction of the wax coating, fractures and cracks are made on the stems. For processing legumes, it is recommended to use rubber rollers that rotate at the same speed with helical protrusions and depressions, and the protrusions of one roller go into the depressions of another. Bile air conditioners more actively process the mass by stretching it on the corrugated surface located above the rotor. At the same time leaves, inflorescences and parts of stems break off.

Experimental study of the process of processing grass with flattening ribbed rollers was carried out using a self-propelled mower-conditioner E-303 (Fig. 2) on crops of red clover according to the methods [7].



Fig. 2. General view of the E-303 (a) mower and flattening roller (b) Source: author's proposal

The influence of compression force and location of ribbed rollers (Fig. 3) of the mower relative to each other on the moisture transfer process was studied.

In order to facilitate and reduce the amount of work in the study of the drying process of plant mass in accordance with the recommendations of GSTU 46.031-2003, only the first sample of wet raw materials was taken. To do this, mass samples were taken from the total sample, crushed and placed in prepared numbered boxes, in which the samples were dried in an oven at a temperature of 100 °C to constant weight, and then calculated the moisture content as a percentage.

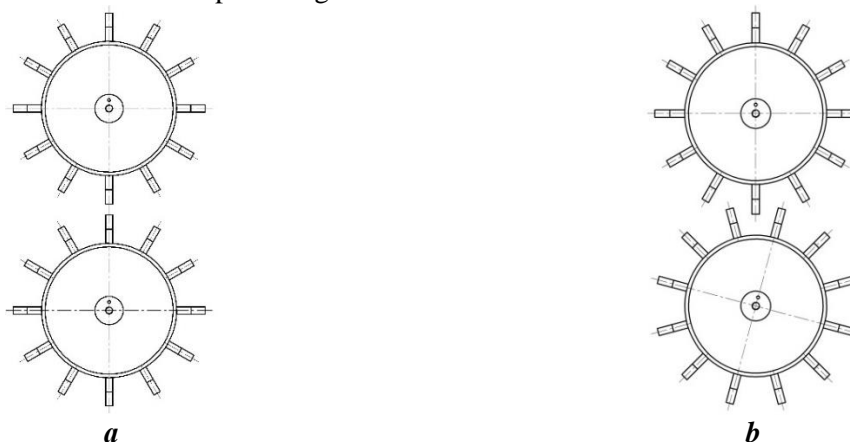


Fig. 3. Location of the ribs of the flattening rollers of the mower E-303 opposite each other (a), with an offset relative to each other (b)



Mesh pallets were used for subsequent humidity control (Fig. 4).

The flattened mass was placed on mesh pallets, which were installed on the stubble at the height of the location of the formed roll. A layer of beveled mass corresponding to the width of the formed roll and one meter long is placed on the pallet. The use of pallets allows to form arrays of raw materials not only processed by rollers in a special way, but also the corresponding mass per square meter. This allows to assess the effect of machining on the drying process, avoiding the effect of differences in the density of the mass per meter of roll. Mesh pallets were weighed at fixed intervals during daylight hours. Temperature and relative humidity were recorded. Observations were carried out before the plant mass of hay reaches 17-18%. The obtained

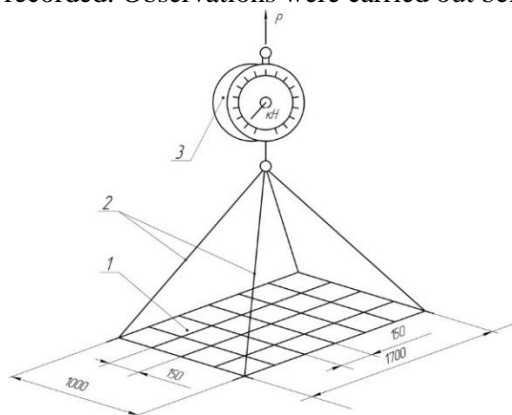


Fig. 4. Mesh pallet for studying the process of drying the mass in the field: 1 – mesh pallet; 2 – slings; 3 – dynamometer

results were processed using elements of mathematical statistics. The repetition of experiments is not less than triple. Graphical dependences were built on the basis of the obtained results to facilitate the analysis (Fig. 5).

The rate of moisture transfer was determined by the ratio:

$$\frac{dW}{dt} = \frac{W_1 - W_{i-1}}{t_1 - t_{i-1}}, \quad (1)$$

where $\frac{dW}{dt}$ – moisture transfer rate, % / hour;

W_1 – actual humidity of the mass, %; t_1 – drying time, hour; $W_1 - W_{i-1}$ – humidity measurements during the drying period of the samples, %; $t_1 - t_{i-1}$ – interval between measurements, hour.

Studies of the drying clover mass have revealed that increasing the compression force of the rollers (Fig. 5) accelerates drying. However, no less important factor in determining the drying rate is the density of the mass (curves 1 and 2). This is due to the fact that the linear density of the mass in obtaining dependence 1 was 6.89 kg/m², and in obtaining dependence 2 and others - 8.83 kg/m². Dependencies 2 and 3 were obtained for the location of the rollers according to option b (Fig. 3a), but dependence 3 was obtained for the compression force of 1.85 H/cm of the length of the roller rib, while the dependence 2 - 1.5 H/cm. Increasing the effort leads to increased destruction of the raw material, respectively, to accelerate the drying of the mass in the roll. Even greater acceleration of the drying of the mass leads to the installation of rollers rib against rib (dependence 4). Thus, the location of the ribs against each other accelerates the drying of the mass as much as possible, which is caused by the improvement of plant destruction conditions in the inter-roller gap.

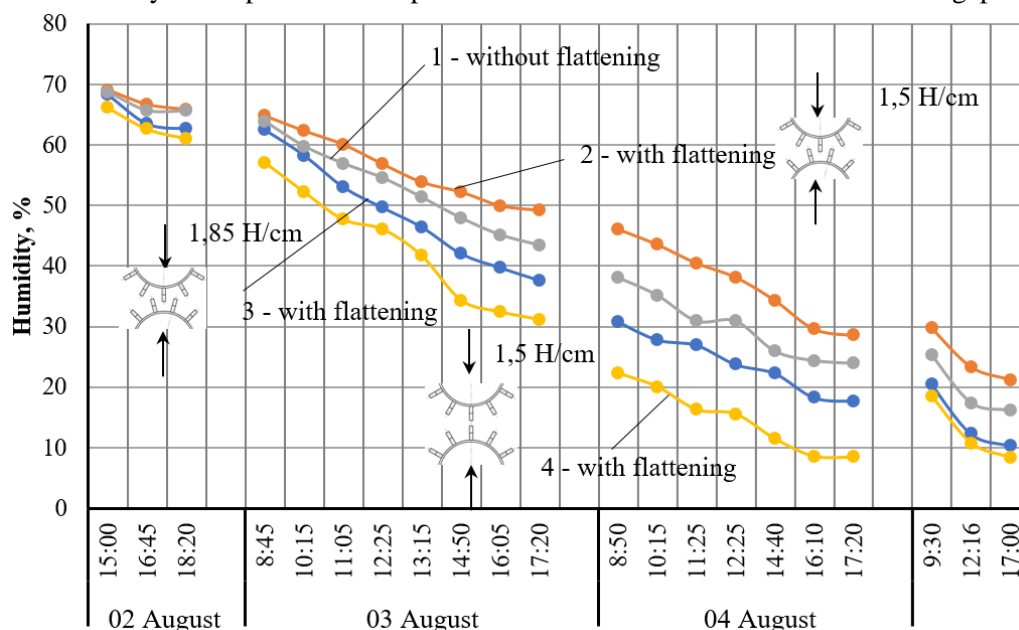


Fig. 5. Dynamics of clover roll drying

Studies by other authors [8, 9] found that in poor conditions for four days can bring the humidity of the mass to only 50 – 60 % [9]. In hot weather it is possible to get the mass with the humidity of 17-20 % in two days [8].

Thus, the use of roller air conditioner mower E-303 allows to get the weight for hay for 2-3 days after mowing, which is less per day than mowing without weight conditioning. The obtained results allow to recommend the installation of rollers with an edge in front of the edge for accelerated drying of the mass, which allows to accelerate the drying process by 9-12 hours.

Such manufacturers as Claas, Kuhn, Krone, Pöttinger produce mowers with both types of air conditioners, some models of trailed mowers are offered to the consumer with removers air conditioners of both types. The use of air conditioners on mowers accelerates the drying of stems and provides more even drying of the mass and avoids a separate operation with the passage of units in the field.

For each pass of the mower three rolls were formed. To intensify the drying of the mass immediately after mowing, they were spread with a hay tedder Volto 1320T with a design width of 13 m (Fig. 6). The working width of the mower was 11.5 - 12.3 m. To ensure the required pace of work, the width of the mower should exceed the total width of the mowers used in 1.6-1.7 times, as the working speed of the mower should be 7-8 km/h. This speed provides high-quality copying of the field surface, minimizes contamination of raw materials by soil particles.

*a**b*

Fig. 6. Trailed grass turner Volto 1320T in work: a) – when moving in the folded state, b) – during agitation, side view Source: author's proposal

When the humidity of the raw material reaches 50-55 %, it should be raked into rolls. This indicator is especially critical for legumes, because due to the uneven drying of the leaves at lower humidity, the latter is upholstered and lost during raking.

To reduce them, legumes raking is carried out in the morning and evening at low engine speeds, when the humidity rises slightly. If necessary, legumes are raked at night. In addition to the requirements for drying hay, the raking operation ensures the productive work of mechanization in picking operations. The rakes issued in Ukraine have a width of capture of 4,2-6,0 m. Such rakes provide timely performance of works on sites to 50-80 hectares forming linear thickness of a roll of 3-4 kg/m. The desired power of the roll is 2-3 times greater. Therefore, preference should be given to rotary rakes with a working width of 12 - 18 m. This is due to the quality of their work, reliable performance of the technological process.

Rakes of leading companies have a modular design and are offered with one, two (with the central or lateral laying of a roll) and four rotors, forming one or two rolls in one pass. The design and number of rotor rakes provides high productivity and laying of loose rolls. The rotor drive does not require daily maintenance. Thanks to the three-, four-wheel supports under the rotors, they qualitatively copy the field surface and have almost no losses when raking. Figure 7 shows a four-rotor hay tedder Liner 3600.

Using a four-rotor rake Liner 3600 after drying alfalfa to a humidity of 54.10 % received a working width of the rake 11.81 m, which ranged from 11.5 to 12.0 m. The width of the roll formed was 1.8 - 2.6 m, the average working speed was 9.32 km/h, which was slightly higher than the speed of the hay tedder.

To avoid losses from upholstery, it is advisable to dry the raw material in a roll. In cloudy weather, the roller can be moved by two rotors of the rake, shifting it by 2.0-2.5 m to the side.

When the roll reaches a moisture content of 17-19 %, the hay should be selected. It is advisable to harvest hay in pressed form, as it greatly facilitates the accounting of feed, transportation and storage of hay.

However, hay in bulk is also harvested on farms, because it is in bulk that it can be dried by active ventilation. The use of pick-up trucks avoids transshipment operations. They perform operations on weight selection, loading into the body with pressing and transportation to the place of storage. This minimizes costs

and simplifies the logistics of work. Such manufacturers as Claas, Krone, Pottinger offer similar designs, differing in body volumes, which are in the range of 22-100 m³. For feeding into the trailer, cutting the mass, they use a biter-knife cutting machine with a rotor with a diameter of 750-880 mm, with 7-9 rows of fingers in a circle and a set cutting length of 34-45 mm. The bottom conveyor is used to unload the mass.

Round balers are distinguished by their simplicity (structural and technological), and form cylindrical rolls with a diameter of 0.6-1.8 m, a length of 1.2-1.5 m with a density of 120-140 m³. There are balers with cameras of constant and variable volume. In balers of the first type, the chamber divided in half is formed by drums or strips on a flexible carrier (usually a chain). The roll formed in such a chamber has a core of low density. Chambers of variable volume form loops of several flat belts. The belts are tightened with constant effort, so the mass in the chamber is compacted from the very beginning of the formation of the roll. The result is a roll with a denser core.

Presses differ by other features. Tying with twine takes place when the press is stopped. The faster the roll is tied, the higher the productivity of the press, so use knitting at the same time with two threads instead of one. And the use of the grid allows to complete this operation in 2-3 turns of the roll. Manufacturers sometimes install both tying systems on modern presses. Depending on the raw material (hay, straw) it is determined which of the systems will be used. Another feature is the use of an integrated auger rotor in the mass supply system. It allows to narrow the mass to the width of the roll and forcibly direct the mass to the chamber. The rotor is a drum with screws installed on the edges, and in the central part of the drum - fingers for feeding mass. Installation in a zone of movement of weight of knives allows to receive the biter-knife cutting device. Knives for protection are usually installed spring-loaded with the possibility of exit from the channel. The system evenly feeds the mass into the chamber, and the cut mass is better compacted and easier to mix in the feeder - mixers.

*a**b*

Fig. 7. Four-rotor rake Liner 3600 in work (a), rotor of a rake (b) Source: author's proposal

Large-pack balers work most productively on hay. On the Ukrainian market they are offered by Claas, Kuhn, Krone, Klaas, Kuhn, Krone, Massey Ferguson, New Holland and others. The maximum section of bales formed by them is 0,8-1,2 × 0,7-1,3 m², and length can be regulated to 2,5-3,0 m. Density is regulated within 120-300 kg/m³. Most often, bales measuring 1.2 × 0.9 × 2.5 m and weighing 300-500 kg and 1.2 × 1.2 × 2.5 m weighing 500-650 kg are formed. Such dimensions make them suitable for transportation, storage and warehousing. The weight of the presses is in the range of 7 - 10 tons. Such machines from leading manufacturers have their own workflow control system, the terminal of which is located in the tractor cab. For efficient use of the baler, it should be combined with a tractor of appropriate power (over 200 hp), which has the ability to connect pneumatic, hydraulic and electrical systems.

In addition to the sorter, feed rakes, finger beaters, and augers are used to feed the mass, narrowing the mass to the width of the bale. The presses used a pre-pressing scheme, in which the hay is collected and partially compacted in a curved channel in three strokes of the packer, fed into the pressing chamber. The supply of hay to the chamber is lower. In the chamber, the hay is finally compacted by a piston, in the drive mechanism of which a flywheel is provided. When the specified length of the bale reaches the signal to the knitting mechanism and the needles at the time of maximum compression of the mass through the channels in the piston feed the twine to the knotter. double knot knitting is used. The most reliable is the design of Claas knotters, which is almost 100 years old. It, at the invariable scheme, is constantly improved and bales are knitted by a single knot. Thus, the Quadrant 3200 has thickened hollow pins, improved thread extender and twine clamp. Modern models must use a system of pneumatic cleaning of knotters from plant debris. After that, the bale is pushed out of the pressing chamber by mass from which the next bale is formed.



Modern presses are equipped with cutting devices, similar to devices of round balers, electronic devices for control of process, humidity of weight, the account of the executed work.

For loading of bales which are in the field and in storage it is expedient to use telescopic self-propelled loaders. For storage of rolls to loaders there are specialized captures which give the chance to stack rolls in horizontal or vertical position.

6. Conclusions

During the haymaking, as well as other fodder, it is necessary to take into account a systematic, comprehensive approach to the organization of work, staffing a set of technical means, their preparation for work, the collection and subsequent storage of feed.

First of all, the required volumes of fodder, defined crops and provided areas for sowing should be calculated taking into account stocks. The highest quality hay is obtained from legumes and legume-cereal mixtures. Hay should be harvested from less productive second, third slopes.

To obtain high-quality hay technical means that accelerate the drying of grass in the field should be widely used: flattening conditioners, hay tedders, rakes, and ventilation systems with heated air for hay drying.

Mowing work should be started on any slope in such a way as to complete mowing for legumes at the end of the budding phase and for ear crops at the beginning of earing. Procurement work should last no more than four days. The height of mowing the grass is 8-10 cm. The cut should not be torn, the stubble should not differ in height. Working speed for rotary mowers is 10-12 km/h and more, for segment-finger mowers up to 7-9 km/h.

For processing legumes, it is recommended to use rubber rollers that rotate at the same speed with helical protrusions and depressions, and the protrusions of one roller go into the depressions of another. Bile air conditioners more actively process the mass by stretching it on the corrugated surface located above the rotor. At the same time leaves, inflorescences and parts of stems break off.

Studies of the drying of the clover mass have revealed that increasing the compression force of the rollers accelerates drying. The use of a roller air conditioner mower E-303 allows to get the weight for hay for 2-3 days after mowing, which is less per day than mowing without air conditioning weight. The obtained results allow to recommend the installation of rollers with an edge in front of the edge for accelerated drying of the mass, which allows to accelerate the drying process by 9-12 hours.

To reduce losses due to upholstery of inflorescences and leaves, raking of legumes should be carried out in the morning and evening at low engine speeds, when the humidity rises slightly. To avoid losses from upholstery, it is advisable to dry the raw material in a roll. In cloudy weather, the roller can be moved by two rotors of the rake, shifting it by 2.0-2.5 m to the side. When the roll reaches a moisture content of 17-19 %, the hay should be selected with balers or pick-up trucks. It is advisable to harvest hay in pressed form, as it greatly facilitates the accounting of feed, transportation and storage of hay.

References

- [1] Petrychenko, V. F., Korniyuchuk O. V., Zadorozhna I. S. (2018). Stanovlennya ta rozvytok kormovyrobnytstva v Ukraini. *Visnyk ahrarnoyi nauky*. 11. 54–69 [in Ukrainian].
- [2] Rozhenko, V., Filonenko, L., Balabukha, S. (2014). Suchasna tekhnika dlya zahotivli sina. *Tekhnika i tekhnolohiyi APK*. 12(63). 36–38 [in Ukrainian].
- [3] Savchenko, YU. I., Musiyenko, M. V. (2016). *Zahotivlya kormiv prohresyvnymy tekhnolohiyamy*. Zhytomyr. [in Ukrainian].
- [4] Rudyk, R. I., Savchenko, YU. I., Herasymchuk, V. I. (2016). *Naukovo-praktychni rekomendatsiyi po vyrobnytstvu i zahotivli kormiv*. Zhytomyr. IS-HP. [in Ukrainian].
- [5] Syrovatko, K.M., Zot'ko, M.O. (2020). Tekhnolohiya kormiv ta kormovykh dobavok: navchal'nyy posibnyk. Vinnytsya: VNAU, 263 s [in Ukrainian].
- [6] Mazur, V. A., Balahura, O. V., Zhurenko, YU. I. (2018). Vplyv kil'kosti tekhnolohichnykh operatsiy na fizyko-mekhanichni vlastyvoli biomasy lyutserny pry zahotivli sina. *Vseukrayins'kyi naukovyy zhurnal "Tekhnika, enerhetyka, transport APK"*. 4 (103). 9–17 [in Ukrainian].
- [7] HSTU 46.031-2003 "Mashyny sil's'kohospodars'ki. Kosarky, kosarky-plyushchylky ta kosarky z portsiynym skydannym. Metody funktsional'nykh vyprobuvan'" [in Ukrainian].
- [8] Protokol 23-35-88 Pivdenno-Zakhidnoyi MVS vyprobuvan' kosarky YE-303 [in Ukrainian].
- [9] Protokol 29-91-84 VNYYMOZH vyprobuvan' kosarky YE-303 [in Ukrainian].

**ОСОБЛИВОСТІ ПІДГОТОВКИ ТЕХНІЧНИХ ЗАСОБІВ ДЛЯ ЗАГОТІВЛІ СІНА**

Збільшення виробництва продукції тваринництва потребує корінного вдосконалення кормовиробництва в господарствах і насамперед із заготівлі стеблових кормів як таких, що забезпечують повноцінність годівлі ВРХ. Сучасні технології та технічні засоби заготівлі кормів дозволяють якісно виконувати роботи в агротехнічні строки.

Відмічено, що заготівля сіна, як і інших кормів, передбачає системний, всесторонньо виважений підхід до організації робіт, комплектування комплексу технічних засобів, їх підготовки до роботи, самого збирання та послідуного зберігання корму.

Мета досліджень полягала в обґрунтуванні особливостей підготовки технічних засобів для заготівлі листостеблових матеріалів на сіно для умов сучасного стану розвитку техніки в Україні та світі.

В науковій роботі розглянуто особливості підготовки технічних засобів для заготівлі сіна з бобових трав та бобово-злакових мішанок. Відмічено, що для отримання високоякісного сіна слід широко використовувати технічні засоби, які прискорюють висушування трави в полі: плющилки-кондиціонери, ворушилки, граблі, а для досушування сіна – вентиляційні установки з підігрівом повітря. Обґрунтовані основні заходи, налаштування та підготовка засобів механізації при скошуванні, плющенні, ворушінні та збиранні трав на сіно.

В роботі відмічено, що збільшення зусилля стискання вальців косарки Є-303 сприяє прискоренню висихання валка маси конюшини. Встановлено, що використання вальцевого кондиціонера косарки дозволяє отримати масу для сіна на 2-3 добу після скошування, що на добу менше, ніж скошування без кондиціонування маси. Отримані результати дозволяють рекомендувати для прискореного висихання маси установку вальців ребром напроти ребра, що дозволяє прискорити процес висушування на 9-12 год.

Ключові слова: корми стеблові, заготівля кормів, сіно, сушіння, скошування, плющення, ворушіння, граблі, прес-підбирач, візок-підбирач.

Ф. 1. Рис. 7. Літ. 9.

INFORMATION ABOUT THE AUTHORS

Oleksandr Kholodyuk – Ph.D, Senior Lecturer of the Department of "Operation of a machine-tractor park and technical service" of Vinnytsia National Agrarian University (3, Sonychna St., Vinnytsia, 21008, Ukraine, e-mail: holodyk@vsau.vin.ua, <https://orcid.org/0000-0002-4161-6712>).

Volodymyr Kuzmenko – Ph.D, Senior Researcher, head of the department "Biotechnical systems in animal husbandry and harvesting of feeds" of the National Scientific Center of the Institute of Mechanization and Electrification of Agriculture (11, Vokzalna St., Glevakha, Vasylkivskyi district, Kyiv region., 08631, Ukraine, e-mail: vfkuzmenko@ukr.net, <https://orcid.org/0000-0002-3474-939X>).

Volodymyr Zhukov – Candidate of Agricultural Sciences, Senior Research Fellow, Department of Technology of Feed Production and Use, Institute of Feed and Agriculture of Podillya NAAS (16 Yunosti Ave., Vinnytsia, Ukraine, 21000, e-mail: vladzupk@gmail.com, <https://orcid.org/0000-0002-7845-6222>).

Холодюк Олександр Володимирович – кандидат технічних наук, старший викладач кафедри "Агроінженерії та технічного сервісу" Вінницького національного аграрного університету (вул. Сонячна, 3, м. Вінниця, 21008, Україна, e-mail: holodyk@vsau.vin.ua, <https://orcid.org/0000-0002-4161-6712>).

Кузьменко Володимир Федорович – кандидат технічних наук, старший науковий співробітник, завідувач відділу "Біотехнічних систем в тваринництві та заготівлі кормів" Національного наукового центру Інституту механізації та електрифікації сільського господарства (вул. Вокзальна, 11, смт. Глеваха, Васильківського р-ну, Київська області, 08631, Україна, e-mail: vfkuzmenko@ukr.net, <https://orcid.org/0000-0002-3474-939X>).

Жуков Володимир Павлович – кандидат сільськогосподарських наук, старший науковий співробітник відділу "Технології виробництва та використання кормів" Інституту кормів та сільського господарства Поділля НААН (пр-т Юності, 16, м. Вінниця, Україна, 21000, e-mail: vladzupk@gmail.com, <https://orcid.org/0000-0002-7845-6222>).