An innovative technical solution to the issue of conditioning forage grasses

S A Otroshko, A V Shevtsov, N D Sharikov

Federal Williams Research Center of Forage Production & Agroecology, st Nauchny Gorodok., 1, Lobnya, Moscow region, Russia

Corresponding author e-mail: vnii.kormov@yandex.ru

Abstract. Acceleration of wilting of forage grasses treated during mowing by the working bodies of dynamic conditioners installed on disc mowers is a prerequisite for improving the quality of forage, primarily in terms of the concentration of high-quality protein, vitamins and other biologically active substances, as well as energy. The main working body of modern conditioning devices is a horizontal shaft rotating at a speed of 18-29 m/s with hinged beaters of various configurations placed on its surface, which ensure grass dragging along the surface of corrugated decks, through combs, etc. [1]. Such devices significantly increase the weight of the mowers, which increases their cost by about 1/3, and the use of an additional drive of the conditioner shaft leads to operational difficulties. In this regard, the search for innovative technical solutions aimed at improving this situation is a very urgent task. The article describes the design and principle of operation of a rotary conditioner with a vertical axis of rotation developed in Federal Williams Research Center of Forage Production & Agroecology for the KR-2.1M mower of the “Agramak” company, the articulated beams of which are installed directly on its discs. The mower with an innovative conditioner was tested on a mixture of reed fescue with clover of the first cut and on tetraploid meadow fescue of the second. The yield of green mass, the composition of the herbage, its height and lodging, as well as the phase of development were determined in accordance with the guidelines for conducting field experiments with forage crops. The work of the mower was evaluated according to GOST 28722-90. The article presents data on the degree of damage to treated plants and the dynamics of the rate of their dehydration.

1. Introduction

When harvesting voluminous forage from high-protein perennial grasses in the form of hay, haylage and silage, the wilting of the mowed mass in the field plays a special role. The faster the mass reaches the optimal moisture content, the better the feed is obtained by reducing the loss of nutrients as a result of the respiration of cut plants and the activity of epiphytic microflora, as well as the washing out of soluble nutrients by rains in inclement weather.

The technology for preparing such feed consists of the following operations: mowing, crushing, wilting and raking grass into swaths, picking up grass from swaths with a combine harvester with chopping for silage and haylage and a baler for hay.

The main direction in accelerating the field wilting of the mowed mass is associated with mechanical action on grass stalks with bale-deck conditioners and crimping rollers in the mowing process, installed, as a rule, on disc mowers [2,3,4]. Serially produced dynamic conditioners are
located behind the disc mowers cutterbar and have a horizontal axis of rotation. They process the grass mass with sufficient quality, but strong conditioners are used for cereal grasses, and crimping conditioners are used for legumes. In addition, they are characterized by high material consumption, design complexity, low operational reliability, and high cost.

In the patent and scientific literature there is information about devices for mowing and processing grasses before field drying, which differ from classic dynamic conditioners with a horizontal arrangement of working bodies. They are rotors vertically arranged one above the other with articulated working bodies of the beating-cutting type.

Known rotary mower design L.N. Burkov [5] with cutting elements made in the form of a steel string with a load at the end, placed on the rotors of the mower with a vertical axis of rotation. In this mower, the weights of the odd rotors rotate in one plane, and the weights of the even rotors rotate in the other.

This device is only intended for cutting grass and cannot be used to condition it.

An interesting design is a layered cutting mower-shredder [6], which contains a frame and vertical drive axles with rotary discs with cutting elements mounted on them in several tiers. Rotary discs are installed with a decrease in their diameter from the upper tier to the lower one.

The disadvantages of this device are: the complexity of the design and the impossibility of ensuring the violation of the integrity of plant stems due to their cutting into short segments.

Noteworthy is a mower-conditioner [7], which contains a rotary cutter with an even number of rotating discs, on which knives are mounted and drums with beats are vertically mounted, placed along a helical line on the drum generatrix, the winding direction of which from the drum base is opposite to the direction of mass movement. Decks made of V-shaped and consisting of two parts are placed between the drums.

This device is fundamentally different from classical conditioners, but it has a complex design and is energy-intensive.

In this regard, the search for new technical solutions without the aforementioned drawbacks, ensuring the acceleration of wilting of forage grasses, is a very urgent task.

**Purpose of the research** - development of an conditioner with a vertical axis of rotation, characterized by a simple design, low material consumption and ease of use.

### 2. Research methodology and conditions

Studies of the operation of a disc mower KR-2.1M with an conditioner for mechanical action on the stalks of mowed grass with flat beats, the working part of which is bent at an angle of 135° relative to the working part, was carried out on the experimental fields of the Federal Williams Research Center of Forage Production & Agroecology in accordance with GOST 28722-90 [8], "Methods of field experiments on wilting and drying herbs for silage and haylage" [9], "Guidelines for conducting field experiments with forage crops" [10], as well as guidelines "Conducting experiments on the preservation and storage of bulky feed" [11]. To determine the air velocity, we used an MS-13 hand-held cup anemometer, and a psychrometer for the relative air humidity. When determining the dynamics of wilting of cut grasses, moisture sampling was carried out in accordance with GOST 27262-87 [12]. The selected samples were dried at a temperature of 100-105°C to constant weight in accordance with GOST 27548-87 [13]. Determination of damage to plant stems was carried out visually. To measure the segments in the selected samples, as well as their distribution by fractions, a ruler with a graduation from 0 to 1000 mm was used. Weighing of samples and fractions of damaged plant stems was carried out on an Olimp 1U electronic balance, model MT 15V1ZhA. Testing of the rotary mower KR-2.1M with the developed conditioner was carried out in the field for the first time.

### 3. Results of the research

At the Federal Williams Research Center of Forage Production & Agroecology developed an innovative device for conditioning fodder grasses with dynamic action for a KR-2.1M disc mower manufactured by OJSC “Sasovkormmash” by “Agramak”, which is fundamentally different in all
respects from existing conditioners with horizontally located working bodies and is a beetle hinged on
the discs of the mower, the working part of which is bent at an angle of 135° relative to the working
part. In fig. 1 shows a disc mower KR-2.1M.

![Figure 1. Disc mower KR-2,1M by «Agramak»](image)

Disc mower with rotary conditioner [14], fig. 2, contains a support bar 1 with five rotating discs 2
with knives 3 and beats pivotally mounted on the discs 2. Each beater 4 is made of a curved steel strip
of rectangular cross-section and consists of two planes - fastening, which accounts for 1/3 of the
length of the beater 4 and a working one, which is 2/3 of its length, and contains a triangular stiffener
at their junction. The working plane of the beater 4 is equipped with two striking edges, bent vertically
relative to the fastening plane at an angle of 135° and has a straight end. The horizontal fastening plane
contains a fastening hole located on the side of its rounded end. The fixing hole and the triangular
stiffener are located on the axis of symmetry of each pivot bar 4.

![Figure 2. Disc mower KR-2,1M, equipped with a rotary conditioner designed by Federal Williams](image)

Each pair of blows 4 is installed on each disc 2 diametrically opposite, perpendicular to the blades
3 and is pivotally attached to the mower hubs by means of the mounting holes of the blowers 4, bolts,
spacers, flat washers and Grover washers. Spacer sleeves, installed directly on the discs 2, are
equipped with beads, on which the fastening planes of the beaters rest. The height of the working part of the spacers exceeds the thickness of the fastening planes of the beaters to enable them to rotate.

The diameter of the circle created by the straight ends of the working planes of the beaters does not exceed the longitudinal section of the rotating discs. Depending on the direction of rotation of the discs, when one of the striking edges of the working plane of the beaters is worn, they can be rearranged from one disc to another of counter rotation.

A disc mower with a rotary conditioner works as follows. The torque from the PTO of the tractor is transmitted to the discs located on the support bar, allowing the articulated blades and beaters to rotate at a speed of 3000 rpm, cleanly cut the grass stand and injure plant stems during mowing.

To implement the technological process of conditioning forage grasses in the process of mowing, on discs, beaters are pivotally attached to the mower hubs. To eliminate the phenomenon of imbalance, a mounting hole and a triangular stiffener are located on the axis of symmetry of each articulated beater. The plant mass cut by the hinged knives enters the zone of action of the hinged beaters, which, with the striking edges of the working planes, condition the plant stems (crush, break, cut the cuticle of the stems) and intensively remove them from the processing zone. This is also facilitated by triangular stiffeners welded along the axis of symmetry of beat at the junction of the fastening and working plane. Due to the created air flow and the throwing effect, the mowed, processed mass is thrown out of the processing zone and evenly placed on the surface of the field in the growing plant, which contributes to a significant acceleration of the withering of the mass.

During work, when meeting with an obstacle, for example, a soil bump, stone, etc. the hinged knives and the hinged beaters deviate from their working position and, after passing the obstacle, due to centrifugal forces, return to their original position. For the possibility of deflection when meeting an obstacle, the ends of the fastening planes from the side of the fastening holes are rounded.

The developed prototype of the conditioner, installed on the KR-2.1M mower, was tested at the Federal Williams Research Center of Forage Production & Agroecology in two stages: in the first mowing on a grass mixture consisting of 70% reed fescue (Festuca arundinacea) and 30% meadow clover (Trifolium pratense) and in the second mowing on tetraploid fescue (Festuca pratensis Huds) after harvesting seeds. The cereal-clover mixture of the first cut with a yield of 168 e / ha had a moisture content of 83.83%. The height of cereals was 80 cm, and the height of clover was 28 cm. Experiments during the first mowing were carried out in clear, sunny weather, ambient temperature -26°C, relative air humidity - 58%, wind speed - 2.7 m / s.

When the KR-2.1M mower was moving across the field, the hinged disc blades rotating at a speed of 3000 rpm cleanly cut the grass stand, and the hinged beaters, the working part of which is bent at an angle of 135° relative to the working part, fixed on the mower discs, conditioned (broke, crushed, partially crushed) the stems of the plants and the treated mass was removed from the cutting zone, which was then evenly laid into the growing swaths 1.6 m wide. At the same time, the cutting height was 6 cm. After passing the mower equipped with experimental beaters, an even laying of clover and a tent of fescue was observed reed. In the control variant, the mowed grass mass was laid evenly with the butt back along the direction of the mower's movement.

To determine the degree of damage to the cuttings treated with the new conditioner, samples were taken from swaths with a width of 1.6 m and a length of 0.5 m, that is, from an area equal to 0.8 m² in triplicate.

The samples analyzed contained, on average, 80% of damaged segments of reed fescue stems up to 60 cm long. Red clover plants were completely damaged.

When determining the dynamics of drying mowed and processed grasses, it was found that after 21 hours of wilting, the moisture content of the mass decreased from 83.83% to 68.01%; after 25 hours up to 60.40%, and after 45 hours it reached a humidity of 43.28%. In the control, the moisture content
of whole cut plants after 21 hours of wilting was 74.09%; after 25 hours 63.70%, and after 45 hours - 55.78%.

In the second mowing, testing of the KR-2.1M mower with the developed conditioner was carried out in the experimental field of the Federal Williams Research Center of Forage Production & Agroecology on the lodged grass of meadow fescue (Festuca pratensis Huds) tetraploid in the phase of getting into the tube (lodging -57%), yield 130 e / ha, initial moisture -70.21% in warm weather - 21°C, variable cloudiness, relative air humidity - 68%, wind speed - 2m / s. After harvesting the seeds, the biological massif contained 25% of dead wood. The height of green plants in the straightened state averaged 82 cm, in the natural state - 35 cm.

The KR-2,1M disc mower with an conditioner of a beating type was aggregated with a Belarus 82.1 tractor at a forward speed of 0.89 m / s.

It was found that a mower without conditioning (control) laid the mowed fescue in a tent, and with conditioning, in growing. Moreover, the beaters, the working part of which is bent at an angle of 135° relative to the horizontal working part with triangular stiffening ribs, contribute to the effective removal of mowed and treated plants from the cutting zone.

As in the first cut, to determine potential losses - particles up to 10 cm in length and the completeness of crimping of plant stems, samples were taken from swaths from an area of 0.8 m² in three replicates.

The fraction up to 10 cm contains 7% of the particles of the plants treated with the conditioner. The presence of one to four kinks was observed on the plant stems in fractions from 30 to 70 cm.

4. Conclusion

In the Federal Williams Research Center of Forage Production & Agroecology developed an innovative conditioner for a disc mower KR-2,1M with a vertical axis of rotation, the working bodies of which - beaters - are installed on the discs of the mower and affect the stalks of plants during mowing.

The research carried out on the developed prototype of the rotary conditioner showed that it is quite efficient and meets the specified requirements. A mower with an innovative conditioner efficiently performs the process of mowing and conditioning plants, while clogging of the working bodies was not noted. The conditioner processes up to 80% of the grass-legume mixture.

The use of articulated beaters made of a curved strip of rectangular cross-section, consisting of fastening and working planes located relative to each other at an angle of 135° and containing triangular stiffeners at the junction helps to simplify the design and reduce the material consumption of the rotary conditioner.

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