Study of grinding corn stalks by a roller grinder with different knives positioning

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Abstract*: The work is devoted to the study of the efficiency of the technological process of grinding corn stalks with a roller-grinder. Developed and manufactured roller-shredder, the design of which provides for the possibility of direct (left) and inverted at 1800 (right) installation of the cutting edge of the knives relative to their direction of rotation.*
It was noted that in the range of less than 50 mm the percentage of crushed stems in the cat with the right location of the knives was 20% higher than with the left layout of the knives. The total value of the percentage of crushed stem particles in the range of 0-100 mm for the right was 83.6%, for the left 81.9%. In the range of 101-150 mm the share of crushed stems in the roller with the left arrangement of knives was 11.0%, with the right 7.7%, in the range of 151-200 mm, respectively, 4.6% with the left, and 6.0% with the right, in the range over 201 mm, with the left 2.6%, with the right 3.1%.
The average relative to the total weight percentage of crushed stem particles from the total weight of the fraction was for the range 0-50 mm - 20.3% for the right and 12.8% for the left, the range 51-100 mm - 23.8% for the right and 31.3 % for the left, range 101-150 - 14.8% for the right and 18.2% for the left, range 151-200 mm - 24.1% for the right and 16.8% for the left, in the range over 200 mm - 4 , 7% for the right and 20.9% for the left, respectively.
KEYWORDS: *GRINDING OF CORN STALKS, PLANT REMAINS, ROLLER-SHREDDER, INDICATORS OF QUALITY OF GRINDING*

1. Introduction

The technological operation of grinding and wrapping plant residues is extremely important. This issue is especially relevant when harvesting coarse-stemmed crops, such as corn, sunflower, hemp, canola, green manure and a number of other crops. Under the conditions of timely performance of the operation it is possible to accumulate sufficient moisture in the soil, while creating a nutrient medium for biological processes. Marked operations of grinding and wrapping of stem particles are carried out by special machines. The most common among them are combined units containing a disc harrow and a roller-shredder. Under the conditions of application of such machines the agronomic indicators of uniformity of mixing of the crushed particles of stalks with soil improve, favorable conditions for crops are created.

Growing corn requires extra effort to control the corn borer. The spread of this pest is gaining a threatening rate for culture. Chemicals alone are not enough to solve the problem. Effective pest control results can be achieved by using crop residue shredders. Shredded corn stalk to a size of less than 50 mm makes it impossible for the butterfly to overwinter.

Note the relevance of research aimed at developing special machines that contain rollers. The use of rollers in combined units allows rapid surface tillage with intensive mixing, stubble peeling, cultivation of corn, sunflower, rapeseed fields with a large number of crop residues, pre-sowing tillage and organic wrapping.

2. Preconditions and means for resolving the problem

Note the existence of significant differences in the methodologies of substantiation of rational technological parameters of rollers. This largely applies to both roller shredders used in the mono gun version, and in combined machines.

Fluctuations in a wide range of mechanical and technological properties of the plant environment are among the main factors that determine the quality of work of means for grinding.

Modern tillage systems are based on the analysis of biological characteristics of crops, field condition, agrophysical properties of soils, climatic, organizational, technical, technological and production capabilities of the economy [1].

The most common tillage systems include basic tillage with pre-stubble peeling and appropriate measures of pre-sowing and post-sowing soil preparation [2].

Among the main operations of loosening the topsoil to preserve existing moisture reserves, complete pruning and mechanical destruction of perennial and annual weeds, shallow wrapping of weed seeds in the soil, grinding of rhizomes of wheat and thistle roots, mechanical destruction of pathogens and pests [3].

Stubble peeling is carried out in the next operation after harvesting the predecessor. Such actions contribute to the maximum preservation of soil moisture. This makes it possible to cultivate the field efficiently, without blocks [4].

It should be noted that in the above publications there is no quantitative assessment of the quality of performance of operations of crushing coarse-stemmed crops in the entire range of plant residue sizes.

The article [5] presents the results of research of the machine-tractor unit, which simultaneously performs technological operations of grinding and soil wrapping of plant residues (sunflower stubble). The first operation is performed thanks to the shredder of plant residues, installed in front. The plow installed behind carries out operation of wrapping. However, the issue of determining the impact on the quality of grinding of plant residues of the speed of the unit remained out of the authors' attention.

The machine developed by the authors of the article [6] combined the functions of stubble cleaning and furrow opening. According to the results of statistical analysis, it was concluded that the speed of rotation of the blade, which destroys the stubble, did not affect the resistance of tillage. However, the authors did not pay attention to the issue of determining the influence of the location of the cutting edge of the knife on the quality of grinding sunflower stalks.

According to the results of experimental studies of a two-roller cultivator, the high quality of its work on grinding corn stalks was noted [7]. The rate of shredding of stems reached 90%. However, the authors do not give specific values of the degree of grinding of corn stalks in the ranges 0-50mm, 50-100mm, 100-150mm, 150-200mm, more than 200mm.

The authors of the article [8] on the basis of the developed mathematical model analyzed the conditions of interaction of the stem with the opener. Two types of possible options for the location of knives are proposed, which creates the preconditions for the design of a new type of narrow-band rotary cultivators and shredders of plant residues. However, the authors did not pay attention to the experimental study of the proposed design.

Note the relevance of the development of special machines that contain rollers. Thanks to them, it is possible to quickly perform surface tillage with intensive mixing, stubble peeling, cultivation of fields with a large number of residues of coarse-stemmed crops, pre-sowing tillage and wrapping of organic fertilizers.

3. Purpose of the study

The work is devoted to the study of the efficiency of the technological process of grinding corn stalks with a roller-grinder. Such actions are consistent with the development of systems of measures aimed at combating pests and diseases of culture. The most dangerous are corn butterfly.

The results of this publication are systematically consistent with the work previously conducted and published by the authors [9].

The aim of the research is to increase the efficiency of grinding and wrapping in the soil particles of corn stalks by establishing the quality of grinding with a roller-grinder depending on the location of the cutting edge of his knives. This will enable more effective ways to control pests and diseases of corn, reduce uneven grinding and energy costs, intensify the grinding process.

To achieve this goal, the following tasks were set:

- to investigate the influence of the location of the cutting edge of the knife of the roller-shredder on the quality of the operations of grinding corn stalks;
- to investigate indicators of quality of performance of operations of crushing and wrapping of corn stalks by the combined unit as a part of a disk harrow with a roller-shredder depending on the scheme of an arrangement of a cutting edge of its knives.

4. Results and Discussion

Previous studies have presented the results of the development and manufacture of a prototype roller-shredder, as well as to determine the impact of the location of the cutting edge of the roller blade on the quality of shredding of sunflower stalks [9]. Developed and manufactured roller-shredder, the design of which provides for the possibility of direct (left) and inverted to 1800 (right) installation of the cutting edge of the knives relative to their direction of rotation.

In accordance with the program of complex research aimed at solving the important problem of increasing the efficiency of production of coarse-stemmed crops, a prototype of a combined unit based on a heavy disc harrow was developed and manufactured. The main difference of the above unit is the use of a variable module - a roller-shredder, which allows you to intensify the process of grinding and wrapping to a depth of 25 cm coarse plant residues.

The structural and functional scheme of the combined unit, containing the roller-shredder in combination with the disc harrow BDVP-3,8, is shown in Fig.1.

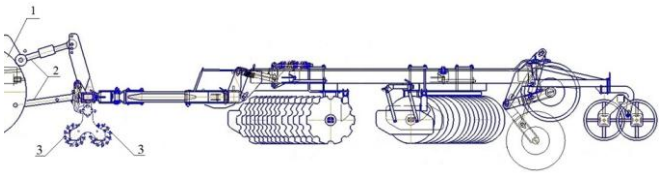


Fig. 1. *- Scheme (side view) of a disc harrow with a roller-shredder for additional grinding of plant residues: 1 - energy means; 2 - coupling device; 3 - knives of a cat-shredder*

The experimental sample of the combined unit (Fig. 2) for tillage and mulching of the soil with crop residues of corn was studied in the conditions of the research sites of SE "Olenivske" NSC "IMESG" (Kyiv region).

Fig. 2*. - Experimental sample of the combined unit for cultivation and mulching of the soil with plant remains*

According to the research program, a single pass was carried out by the combined unit on the agricultural background, which was a flat area of the field after harvesting corn for silage. In the process of research, the indicators of grinding and wrapping of plant remains in the soil were determined by an experimental combined unit.

The experimental sample of the combined unit for tillage and mulching the soil with plant residues was aggregated with T-150K energy. The speed of movement of the unit in all experiments was 7.2 km / h.

The program of experimental researches provided research of indicators of quality of performance of technological operation of crushing and wrapping in soil of stalks of corn:

- roller-shredder with the right scheme of knives;
- a roller-shredder with the left scheme of an arrangement of knives;
- the combined unit containing the roller-shredder with the right scheme of an arrangement of knives;
- the combined unit containing the roller-shredder with the left scheme of an arrangement of knives.

Processing the results of experimental studies according to [10]. The number of crushed stem particles that fall into the established size ranges characterizes the frequency of occurrence in each interval. The grouping of data smoothes out random oscillations of crushed stem particles, which are not characteristic of a large amount of data, preserves the main, characteristic features of the collected experimental material as a whole. The selected number and values of group intervals prevent significant loss of information about the process and do not distort it. In our case, the experimental data were grouped at intervals of the same size, which was due to the method of selection of crushed stem particles.

Note that the total number of shredded remnants of corn stalks roller-shredder was determined by recalculating the total number of shredded stalks, which was collected on the soil surface. The average value of the collected crushed particles was 312 pieces. at an average weight of 414g.

The distribution of crushed corn stalks by the length of the fractions is shown in Fig. 3.

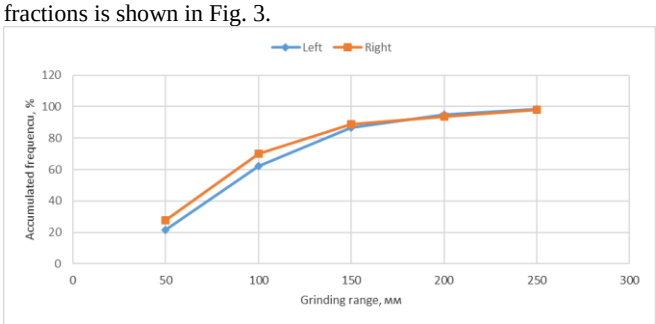


Fig. 3. *- Distribution of crushed stalks of corn crop residues by length of fractions at a speed of 7.2 km / h*

Note that in the range less than 50 mm. the percentage of crushed stalks with the right location of the knives exceeded that of the roller with the left location of the knives by 20%. The total value of the percentage of crushed stem particles in the range of 0-100 mm for the right was 83.58%, for the left 81.89%. In the range of 101-150 mm the share of crushed stalks in the roller with the left arrangement of knives was 10.97%, with the right 7.69%, in the range of 151-200 mm, respectively, 4.59% with the left, and 6.04% with the right, in the range over 201 mm, with the left 2.56%, with the right 3.07%.

Note the excess in the range of 0-50 mm of the average weight of the stem particles in the results with the right location of the knives above the left scheme. This excess of the average weight was, for one sample, the proportion of stems 0.042 g, or 10%.

The average relative to the total weight percentage of crushed stem particles from the total weight of the fraction was for the range 0-50 mm - 20.3% for the right and 12.8% for the left, the range 51-100 mm - 23.8% for the right and 31.3 % for the left, range 101-150 - 14.8% for the right and 18.2% for the left, range 151-200 mm - 24.1% for the right and 16.8% for the left, in the range over 200 mm - 4,7% for the right and 20.9% for the left, respectively.

The roller-shredder with the right arrangement of knives in the range of 0-50 mm was characterized by higher values of the average value of the percentage of total weight and the total

number. This excess was 1.58 times the total weight and 1.2 times the total.

In the grouping interval of 0-50 mm, the probability of crushed particles in the roller with the right arrangement of knives is 27.8%, and with the left - 21.6%. (or 29% more). Exceeding the probability of the interval is 29%.

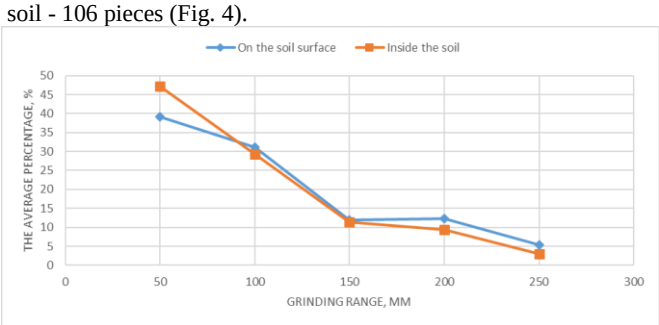
The accumulated probability of the interval 0-100 mm in the roller with the right location of the knives is also characterized by higher values. In the right - 70%, in the left - 62.1%, respectively, and in this interval the accumulated probability of grinding the stems of the roller with the right location of the knives exceeded those of the left by 13%.

The average (weighted by the probability of possible values) value of the random value of the length of the crushed particles of corn stalks for the roller with the right location of the knives was 1 - 65.37 mm for the experiment, 42.814 mm standard deviation and 0.850 coefficient of variation, experiment 2 - 71.06 mm.

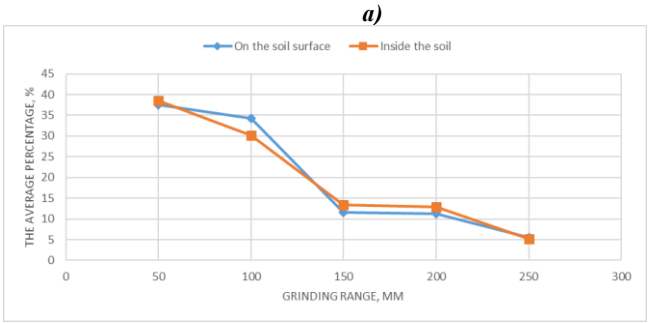
In the roller with the left arrangement of knives, the mathematical expectation was 65.14 mm and 81.33 mm, respectively. That is, the average value of the length of the crushed particles of corn stalks in the roller with the right location of the knives is 5.8% less than the corresponding index of the roller with the left location of the knives.

We note the methodological feature of research to determine the quality of grinding and wrapping plant residues in the soil harrow with a roller (under the right and left placement of knives, as well as mono disk harrow. Collection of crushed residues was carried out both The total amount of crushed residues thus consisted of the sum of residues on the soil surface and those earned on the depth of cultivation with tools.

The average number of crushed parts of the stems in the harrow with the roller was under the conditions of the right placement of knives - 301 pieces, the left - 226 pieces. Under such conditions on the soil surface with the right placement of knives - 115 pieces, in the soil - 186, with the left on the soil surface - 120 pieces, in the soil - 106 pieces (Fig. 4).



a)



b)

Fig. 4*. - Generalized average values of distribution of crushed corn particles for harrow with roller (on the soil surface - 1, inside the soil - 2).*
a - with the right layout of the knives,
b - with the left layout of the knives

In the range less than 50 mm, the percentage of crushed stem particles was:

with the right placement of knives - 39.16%, with the left - 37.48% on the soil surface and 47.18% on the right and 38.5% on the left, respectively, in the soil.

The average number of crushed pieces of corn stalks in the range of less than 50 mm with the right arrangement of knives was 43.17%, and with the left 37.99%. That is, in this range, the harrow with the roller (right location of the knives) by 13.6% exceeded the corresponding values of the tool with the left direction of the knives.

In the range of 51-100 mm, the average percentage of crushed stems for the right direction was -30.19% (31.18% on the soil surface and 29.2% in the soil) and 32.19% (34.28% on the surface and 30,09% in the soil), respectively, for the roller with the left direction of the knives. Analyzing the range of 0-100 mm, we note that the share of crushed stems with the right location of the knives was 36.68%, with the left -35.09%.

That is, the picture of the distribution of crushed stems in the marked range was characterized by a slight excess of the values of the right over the left direction of the knives in the rollers. It is worth noting almost the same pattern of distribution of crushed stem particles in other ranges. Thus, in the range of 101-150 mm, these indicators were as follows: on the soil surface 12.02% in the right and 11.53% in the left, in the soil - 11.36% and right and 11.53% in the left, respectively. In the range of 151-200 mm on the soil surface 12.27% in the right and 11.24% in the left. In the soil 9.31% in the right and 12.95% in the left.

In the range of more than 200 mm on the soil surface 5.37% on the right and 5.47% on the left. In the soil, these figures were 2.95% for the right and 5.16% for the left, respectively.

A significant contribution to the nature and level of damage, shredding of plant residues (sunflower, corn) is made by the working bodies of harvesting machines, engines of technological and transport machines involved in the technological process of harvesting. Thus, the harvester beam resembles the stems with its front part, and the movers, as a result of contact with the stems, break and roll them. Under such conditions, a pattern is formed on the soil surface, which is a combination of different states of stems. First of all, we will highlight the technological tracks, which in most cases do not contain residues of cultivated culture. The second category includes tracks from combines, vehicles, trailers that are involved in the technological process of harvesting and transportation of grain. The third category includes traces of the engines of those vehicles that maneuvered the most convenient route to the combine to load grain and leave the field. These categories of tracks in the field where coarse-stemmed crops were grown, and the analysis of the directions and characteristics of the remaining stem part of the crop, allows us to draw conclusions about the chaotic arrangement of stems. Many of them are broken, partially flattened, sunk into the ground, crushed by engines. The expediency of such an analysis is due to the search for such routes for the movement of rollers on the surface of the field, which would allow the greatest efficiency of grinding and earning crop residues.

However, the chaotic location, lack of dominance and direction of stems, makes it impossible to determine the most rational direction of movement and, accordingly, the type of contact of the working organs of the cat with the stems, which would ensure the most efficient operations of grinding and earning plant parts of stems.

5. Conclusions

Developed and manufactured roller-shredder, the design of which provides for the possibility of direct (left) and inverted to 1800 (right) installation of the cutting edge of the knives relative to their direction of rotation.

A prototype of a combined unit based on a heavy disc harrow BDVP-3.8 was developed and manufactured. The main difference of the above unit is the use of a variable module - roller-shredder, which allows to intensify the process of grinding and wrapping to a depth of 25 cm coarse plant residues. The use of combined units, as well as rollers-shredders in the mono version allows more effective ways to control pests and diseases of corn, reduces uneven grinding and energy costs, intensifies the process of grinding and wrapping.

It was noted that in the range of less than 50 mm the percentage of crushed stems in the roller with the right location of the knives was 20% higher than with the left layout of the knives. The total value of the percentage of crushed stem particles in the range of 0-100 mm for the right was 83.6%, for the left 81.9%. In the range of 101-150 mm the share of crushed stems in the roller with the left arrangement of knives was 11.0%, with the right 7.7%, in the range of 151-200 mm, respectively, 4.6% with the left, and 6.0% with the right, in the range of more than 201 mm, with the left 2.6%, with the right 3.1%.

In the range of 0-50 mm, the average weight of the particles of corn stalks, shredded with a roller with the right location of the knives, exceeded the corresponding grinding rates on the left scheme of installation of knives. This excess of the average weight was, for one sample, the proportion of stems 0.042 g, or 10%.

The average relative to the total weight percentage of crushed stem particles from the total weight of the fraction was for the range 0-50 mm - 20.3% for the right and 12.8% for the left, the range 51-100 mm - 23.8% for the right and 31.3 % for the left, range 101-150 - 14.8% for the right and 18.2% for the left, range 151-200 mm - 24.1% for the right and 16.8% for the left, in the range over 200 mm - 4,7% for the right and 20.9% for the left, respectively.

The average number of crushed corn stalks in the range of less than 50 mm in the combined unit containing a roller with the right arrangement of knives was 13.6% higher than the corresponding indicators of the tool with the left direction of the knives. Under such conditions on the soil surface the percentage of crushed stem particles for the combined unit was with the right placement of knives - 39.16%, with the left - 37.48%, and in the soil these figures were respectively 47.18% in the right and 38.5% in the left.

Analyzing the range of 0-100 mm, we note that the share of crushed stems with the right location of the knives was 36.68%, with the left 35.09%. It is worth noting almost the same pattern of distribution of crushed stem particles in other ranges.

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