Efficiency of application of combing method when harvesting grain crops

Elena B Drepa, Anna S Golub, Inna A Donets and Irina A Walters
Stavropol State Agrarian University, Stavropol, Russia

E-mail: drepa-elena@mail.ru

Abstract. One of the really effective options which can significantly improve the performance of harvesting machines is the equipment of the combing harvester reapers. A significant reduction of the technological mass of the straw entering the threshing device of the combine, reduces load and wear on the working elements of the threshing apparatus and allows for combing at higher speeds. Production costs on the option of direct harvesting has increased with great fuel consumption during the harvest of winter wheat. According to variants of the production costs amounted to 14911.4 when cutting and 14616.9 in the combing plants. The use of harvesting of grain crops by the method of combing increases the profitability of the resulting product. In direct combining, the level of profitability amounted to 63.4 %, when using combing plants – 66.2 %. The combing of the device confirmed its high efficiency, especially in high humidity conditions. The decrease in grain moisture contributed to yield reduction. When harvesting winter wheat with a grain moisture of 16% yield of 3.4 t/ha and 3.3 t/ha, respectively. When comparing two methods of harvesting the difference in yield was 0.2 t/ha. Account yield in the variant with the grain moisture 9 % obtained the following data: in the direct harvesting of 3.1, while the tops of plants of 3.2 t/ha. Sharp decline in the yield suggests that grain moisture 9% is critical in any way of harvesting losses increase significantly due to shedding of grain heap.

1. Introduction
One of the really effective options which can significantly improve the performance of harvesting machines is the equipment of the combing harvester reapers [1].

A significant reduction of the technological mass of the straw entering the threshing device of the combine, reduces load and wear on the working elements of the threshing apparatus and allows for combing at higher speeds. And this, in turn, increase the productivity of harvesting machines (depending on the operating conditions and species of harvested crops) 1.9-2.5 times [2].

The higher the capacity of the combine, the more opportunities to harvest at the moment of its full ripeness before the shedding of grain and to reduce the dependence of harvesting, weather conditions. All domestic and foreign combines performance, loss and damage of grain is primarily determined by the perfection of the threshing and separating device [3; 8; 9].

Among the many unsolved problems of grain production, the most urgent problem of the harvest in the sowing period (7-12 days) and elimination thus significant grain losses and deterioration of its quality. Loss of grain (wheat, barley) from dropping in 20 days after the onset of full ripeness is of 18.4 to 20.2%. Therefore, the most profitable harvest to carry out in a short period, due to agro-technical
deadlines. The provision of these conditions is possible only if farmers have appropriate quantity and quality of the grain harvesters [4; 7].

Reduction of losses during harvesting of contaminated crops is due to the fact that when combing the weeds are not cut off, but only are combed with combs and do not live in the thresher of the combine, which greatly contributes to a better threshing and separation of such crops.

The seasonal threshing of combines using a stripping reaper is almost doubled. Due to this, the crop is not only preserved, but the direct costs of grain harvesting are significantly reduced. So, when equipping the John Deere-9500 harvester with a combing reaper, the direct costs of harvesting grain are reduced by 20%, and the seasonal running time for grain alone is increased by 47% and amounts to 1255 ha. The straw that remains after combing the grain is seized, crushed and used as organic fertilizer, which can significantly compensate for the humus depletion of the earth. If necessary, the straw can be cut into rolls by rotary mowers and used for other purposes [5].

Thus, the equipment of combine harvesters with stripping reapers makes it possible to significantly (1.9-2.2 times) increase the productivity of combines and collect the bulk of grain crops in agrotechnical terms with minimal grain losses and save fuel.

2. Materials and methods
The studies on the combing method were at the experimental station of the Stavropol State Agrarian University on the basis of production crops of winter wheat variety Zustrich.

The goal of this research is to examine the ability and efficacy of harvesting of grain crops by the method of combing plants using the combing harvester

To implement the objectives of the study should undertake the following tasks:

- To study the influence of combing method to remove waste plants on the yield of winter wheat
- To determine the influence of combing method to remove waste plants on the main indicators of quality of grain of winter wheat
- To study the influence of combing method to remove waste plants on the performance of the processor and the amount of the loss

Scheme experience. At the experimental station of the Stavropol SAU laid the experience for the testing of the harvesting of crops by the method of combing plants. As a research objects were used winter wheat varieties Zustrich.

Experience in triplicates, the area of the experimental plots in crops of winter wheat amounted to 0.80 ha.

The main surveys and surveillance conducted in the experience:

- determination of purity of the seeds and injury to the grain;
- definition of seed and baking quality grain;
- definition quality and combing performance of the harvester.

The grain harvest is carried out at different humidities with subsequent decline. Harvests of winter wheat were conducted at a humidity of 20%, 16 %, 12% and 9 %.

Each cut was accompanied by a selection of grain samples with subsequent determination in the laboratory grain quality indicators.

3. Results and discussion
The most important indicator for any culture is its yield. The value yield is the integral indicator of the productivity of plants. It is defined by light and temperature regimes, moisture availability of the soil, the level of mineral nutrition and biological characteristics of the variety.

One of the final stages of agro-technical measures in the cultivation of winter wheat is the choice of the method of combing. It is the method of harvesting can reduce losses and significantly increase the
yield of winter wheat. But not only the amount of losses accounted for in the production of harvest units, but also their performance.

Despite the fact that the capabilities of all existing constructions of modern grain harvesters has almost reached the peak of its technical perfection, there are still numerous reserves for improving their performance. According to many experts, one of the really effective options which can significantly improve the performance of harvesting machines is the equipment of the combs of harvesters reapers [6; 10; 11].

In the experimental station of the SSAU was tested a new method of harvesting the winter wheat method to remove waste plants using the combing harvester production “Penzmash.”

Relying on research, it can be argued that the combing of the device confirmed its high efficiency, especially in high humidity conditions. In this regard the harvesting of winter wheat was carried out at a humidity of 20 %, 16 %, 12 %, 9 % (table 1).

| Indicator    | Direct combining repetition | Plantcombing method repetition |
|--------------|----------------------------|-------------------------------|
|              | I  | II | III | average | I  | II | III | average |
| Grainmoisture 20 % | 3.3 | 3.1 | 3.1 | 3.1 | 3.0 | 3.2 | 31.7 | 31.3 |
| Grainmoisture 16% | 3.6 | 3.3 | 3.2 | 3.4 | 3.2 | 3.2 | 34.2 | 32.7 |
| Grainmoisture 12 % | 3.5 | 3.3 | 3.3 | 3.4 | 3.1 | 3.1 | 36.5 | 32.6 |
| Grainmoisture 9 % | 2.9 | 3.0 | 3.4 | 3.1 | 3.3 | 3.3 | 31.1 | 32.2 |

Table 1. Productivity of winter wheat at different grain moisture, t/ha.

Accuracy of experience, Sx, %

| Variety | Direct combining | Plantcombing method | Average |
|---------|-----------------|---------------------|---------|
| Zustrich | 3.4             | 3.5                 | 3.45    |

Table 2. Productivity of winter wheat depending on the method of harvesting at 14% humidity, c/ha

The analysis of the obtained yield showed the following results. When harvesting grain of winter wheat with a moisture content of 20%, the yield during direct combine harvesting and harvesting averaged 3.1 t/ha.

A decrease in grain moisture contributed to a decrease in yield. When harvesting winter wheat with a grain moisture of 16 %, the yield was 3.4 t/ha and 3.3 t / ha respectively. When comparing the two harvesting methods, the difference in yield was 0.18 t / ha. But hasty conclusions should not be made, since the experience has only been tested and needs additional correction.

Also, winter wheat mowing with a grain moisture of 12% was used as an option. There was practically no difference in yield with previous mowing (3.3 t/ha). Accounting for yield on the option with grain moisture of 9 %, the following data were obtained: with direct combine harvesting 3.1 and with combing plants 3.2 t/ha.

A sharp decrease in productivity suggests that a grain moisture of 9% is critical and with any method of harvesting, losses increase significantly due to shedding of grain heaps.

On average, the yield of winter wheat when converted to 14 % humidity was 34.8 c / ha with direct mowing and 34.7 c / ha when harvested by combing (table 2).
method of harvesting grain crops by the combing method, since this reaper was set up in the course of the experiment and numerous shortcomings are associated with the technical disadvantages of this device.

The principle of operation of the combing reaper consists in threshing by combing with combs located on the drum of the reaper. In this case, the stem of the plant is captured by combs and stretches through the gap between them, freeing itself from grain (seeds). Bread mass, up to 80% consisting of free grain, under the action of inertia and air flow moves to an inclined chamber, which feeds it to the combine threshing for grinding and separation.

Grain which has died and has been exposed to adverse weather conditions: as a result of the reverse stroke of the stripping rotor, it becomes possible to harvest grain that has been killed and beaten by hail from the ground.

As a result of applying the tow principle, grain and a small part of straw are fed to the combine, which increases productivity and reduces losses. So, when harvesting winter wheat by the combing method, the losses amounted to 1.2-1.5% depending on the moisture content of the grain during the harvesting period, while harvesting by the direct combining method, the sweating amounted to 1.3-1.7% (table 3).

| Indicator                        | Direct combining | Plant combing method |
|----------------------------------|------------------|----------------------|
| Combinespeed, km/h               | to 6             | to 12                |
| Harvestlosses, %                 | 1.3-1.7          | 1.2-1.5              |
| The distribution of plant residues on the surface, % | 70               | 100                  |

The obtained data are somewhat at odds with the literature data, but the explanation of this result is the use of the combing harvester for the first time and the technical shortcomings of designers.

One of the advantages of the combing harvester is quite high speed in combing and lower fuel consumption. So the speed of movement of the unit with the combing reaper was 12 km/h, while the combine is equipped with the usual skewing by the reaper has a top speed on the field no more than 6 km/h. Due to the increase in speed is a reduction in fuel consumption per 1 hectare. in the calculation of the economic efficiency of these methods of harvesting fuel consumption combine with the combing reaper was 1.7 times lower than that with the skewing of the combine reaper.

When using the combing reaper, the harvester remains only to transport grain into the hopper. This means higher yields, more thorough combing of seeds and increase the speed of harvesting.

Important in modern conditions is the distribution of stubble on the soil surface to create a natural organic substance. When using direct combining, with chopper vegetable residues are fairly evenly distributed across the field. Approximately 70 % of the surface was covered with straw. If you use the same combing method to remove waste distribution of plant residues on the surface was 100 %, since all stubble remained on the vine. It should be noted that combing stubble provides a good basis for zero technologies and contributes to the protection of soils from erosion and increased accumulation of moisture in the autumn-winter period.

Harvesting should begin at the moment of the maximum biological yield, after the onset of full ripeness of grain and finish in a very short time to avoid loss from dropping grain and reduce its quality in overgrowth in the root or finding rolls. However, with the drastic reduction of the harvesting, the farm will incur a loss due to the additional acquisition of equipment and the cost of its operation.

One of the sowing qualities of seeds is their purity. Purity of seed is the seed material seeds of the main culture, expressed in mass percent. When the harvesting of winter wheat varieties Zustrich by direct combining the seed purity was 92 %, and the combing method to remove waste plants is 96 %. From the above data it can be assumed that the grain heap, arriving in the combing contains less straw and high stubble allows you to cut weeds located at the bottom layer (table 4).
The highest values of seed quality of winter wheat as observed by direct combine harvesting and combing method to remove waste plants. In the absence of injury to the seeds laboratory germination – 95-98% by direct combine harvesting and 94-99%, when combing method to remove waste. In the analysis of the samples revealed that neither by direct combining, when the combing method to remove waste plants crushing of grain is not detected. Therefore, differences in seed germination have not been identified.

**Table 4.** The main physiological and qualitative indicators of winter wheat grain of the Zustrich variety.

| Indicator                  | Direct combining | Plant combing method |
|----------------------------|------------------|----------------------|
| Seed germination, %        | 97,3             | 97,0                 |
| Germination energy, %      | 29,0             | 28,0                 |
| Seed purity, %             | 92,3             | 96,1                 |
| Grain nature, g/l          | 752              | 755                  |
| Mass 1000 grains, g        | 40,3             | 39,1                 |
| IDK, quality group         | 90/II            | 91/II                |

In determining the mass of 1000 grains and the nature of grain any dependence on the method of combing not identified. The mass of 1000 grains on average across all options was 39.7 g, and the nature of 754 g/l. Based on the analysis of the obtained data we can conclude that the quality indicators of gluten, less dependant on farming practices, and to a greater extent on weather conditions and moisture during the growing season and the availability of plant available nutrients, especially nitrogen. The proof is said to show grain quality indicators of winter wheat. Indicators IDK of samples obtained by direct combining were within 89-91 and when combing method to remove waste – 90-91. The average IIR for the option to use the skewing of the reaper was 90, and the option of using the combing harvester – 91. Quality of gluten in all samples - II, which corresponds to satisfactory weak gluten characteristics. In general, the analysis of all samples based on grain quality from the method of harvesting is not revealed.

Using the winter wheat harvest method of combing plants, these figures change. The profit on the option using the combing amounted to 9673.1 rubles/ha, while in direct harvesting 9448.6 rubles/ha. In this case the money received proceeds from grain, respectively, was 24360.0 rubles/ha and 24290.0 rubles/ha.

But production costs on the option of direct harvesting has increased with great fuel consumption during the harvest of winter wheat. According to variants of the production costs amounted to 14911,4 when cutting and 14616,9 in the combing plants.

In conclusion we can say that the use of harvesting of grain crops by the method of combing increases the profitability of the resulting product. In direct combining, the level of profitability amounted to 63.4 %, when using combing plants – 66.2 %.

**References**

[1] Fadeev L V 2011 The use of the combing harvesters – a guarantee of timely harvest without losses http://urozhayna-gryadka.narod.ru

[2] Tarasenko A P 2003 Reduction of injury to seed during harvesting and post-harvest processing *Voronezh: FSEU HPE Voronezh state agrarian University* 331

[3] Kurilov L A 2004 The combing harvester is a new technology of grain harvesting on the vine *Zorya of Poltavshchyna* 176 15

[4] Probasco L A 2009 Biometrics stalk as an external factor of the operation conditions of the combing device *Collection of scientific articles* 21-2

[5] Doronin E F 2009 Timely harvest without losses *Tractors and agricultural machinery* 4 21-4

[6] Lakin V M 2010 Kinematics of the single-drum the combing adapter *Tractors and agricultural
[7] Didier V K, Ridniy S D, Drepa E B and Fustochenko A Y 2011 The Use of harvesting of grain crops by the method of combing plants *Modern resource-saving technologies of cultivation of agricultural crops in the North Caucasus Federal* (Stavropol: Stavrop. the publisher Paragraph) 168-70

[8] Aldoshin N 2015 In Mechanization of harvesting of mixed crops by the method of the tow *Innovative directions of development of technologies and technical means of mechanization of agriculture: materials of international scientific-practical conference dedicated to the 100th anniversary of the Department of agricultural machinery engineering, faculty of Voronezh state agrarian University named after Emperor Peter I.* (Voronezh: FSBEU HE Voronezh state agrarian UNIVERSITY) 192-19

[9] Aldoshin N 2016 In. Cleaned mixed grain crops by the method of tow *Vestnik of FSEU HPE Moscow state Agroengineering University named after V. P. Goryachkin* 1(71) 7-13

[10] Driver V K, Drepa E B and Popova E L 2011 Resource-saving technologies of soil treatment and sowing of agricultural crops in the Stavropol territory *Proceedings of the Orenburg state agrarian University* 4 34-6

[11] Drepa E B and Popova E L 2011 Improving the technology of cultivation of agricultural crops in the grain-field crop rotation *Vestnik APK Stavropolya* 2 12-4