Features of snow retention and counteraction to wind erosion of soils due to high stubble residues formed by a reaper designed for two-phase harversting by batch method

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Abstract. The article deals with issues related to the territorial and climatic features of agricultural activities in the Russian Federation. Due to the large area of the country, the conditions for agriculture in different regions may differ greatly. At the same time, a significant part of the territory is affected by soil erosion. The main types of erosion are considered. The essence of the process of wind erosion or deflation and its key features are analyzed. In addition to soil erosion, insufficient soil moisture was noted as a disadvantage in a number of regions. A number of solutions to these problems are considered. As a solution to the problem, it is proposed to use a Reaper for two-phase harvesting of grain crops, which is equipped with a device for forming strips of high stubble residues. Formed high stubble residues provide snow retention and allow to counteract soil erosion. The paper deals with General issues of technology and design of the proposed machine. The results of theoretical and experimental field research related to the issues under consideration are presented.

1 Introduction

The territory of the Russian Federation occupies a very large area. Without denying the positive aspects caused by this fact, it is worth noting the presence of various organizational and economic difficulties due to this. So, speaking about the agricultural complex, in various regions of Russia, you can find a wide variety of soils, their combinations, climatic conditions and terrain features. At the same time, it should be taken into account that with such diversity in our country, only a quarter of the territory has favorable conditions for the cultivation of agricultural crops. At the same time, a much larger part of the land is subject to adverse impacts, one of which is pronounced wind erosion or deflation, which can occur even on completely flat areas [1].

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2 Methodology

Soil erosion is generally understood as a set of interrelated processes of separation, transport and deposition of soil by wind and surface runoff of temporary water flows. There are different types of erosion and its classification (figure 1). It should be noted that the main types of erosion are wind, water and irrigation [2].

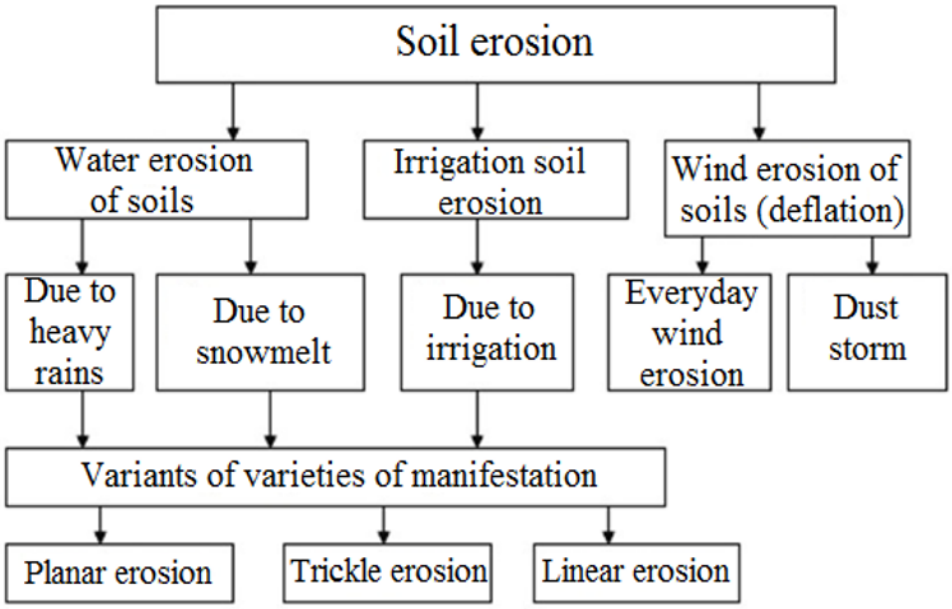

Fig. 1. Classification of soil erosion

When wind erosion, or, in other words, soil deflation, decreases the power of the humus horizon, and in some, but not infrequent cases-the power of the entire soil profile.

The degree of danger of erosion can be judged by comparing the intensity of soil destruction with the speed of the soil-forming process. If the intensity of soil loss is greater than the rate of soil formation, it is considered accelerated [1].

In the Middle Volga region, Central and southern Urals, one centimeter of Chernozem is formed about 100 years, which corresponds to an annual accumulation of 0.6-1.3 t / ha of soil. To date, the destruction of the soil with conventional dump plowing is 4-7 t / ha, i.e. in one year, the fertility accumulated over 10-30 years is lost In addition, deflation changes the entire appearance of land masses and the properties of their soils.

Wind erosion is currently widespread in areas with unstable and insufficient moisture, located mainly to the South of the line passing through the Volgograd, Saratov, Samara, and Orenburg regions, partially capturing the territories of Bashkiria, Chelyabinsk Region, and Northern Kazakhstan [2].

Based on the above, measures are needed to eliminate the manifestations of erosion and prevent its origin. However, you should look for a solution that does not carry both unnecessary costs and does not imply additional impact of special machines on the soil.

Effective and inexpensive measures to counteract erosion include the formation of strips of high technological vegetation or high stubble residues that are significantly higher than the rest of the vegetation in the field. The mechanism of action of these measures is twofold: first, they create a protective zone on the leeward side of high vegetation, and secondly, they serve as a filter that detains soil particles carried by the wind. In addition,

tall plants and tall plant residues serve to accumulate and evenly distribute snow over the field in winter [1].

There are several ways to create lanes with high vegetation (figure 2). Strips of high-stemmed crops require additional measures, starting with their sowing. Artificial high elements as an alternative to strips with high vegetation and high plant residues have not found application in agriculture, the main attempts to introduce them are related to measures to prevent the railway track from being covered with snow.

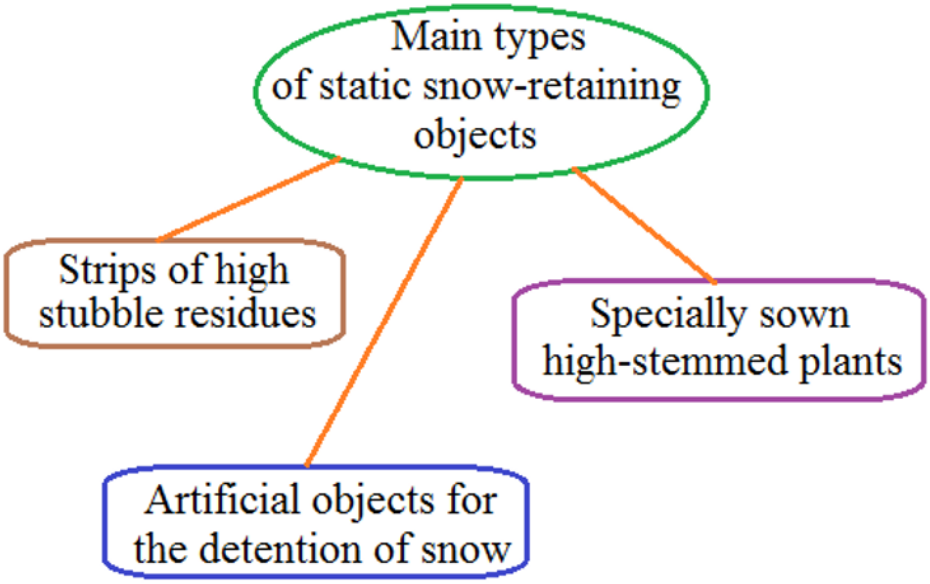

Fig. 2. Main types of stationary snow-retaining objects

High stubble residues, which can be used to form the strips in question – are usually high stubble that is specially left during harvesting. This method is interesting from the point of view of saving and minimizing the impact of heavy agricultural machines on the soil, since it can be implemented simultaneously with the process of harvesting grain crops. Accordingly, it would be logical for the formation of such stubble residues to equip the reaping machine with a special device. However, it is necessary to justify the choice of the reaping machine itself.

In recent years, the average grain yield in the Orenburg region is 10 C / ha, which is quite low. At the same time, in some administrative regions, the yield does not exceed 3-5 C/ha. In such conditions, farmers often do not harvest their crops, as they do not allow them to recoup their costs. Modern combine harvesters, due to incomplete loading, even with more acceptable yields, operate in unexpected conditions, which negatively affects their condition. This should take into account the high energy consumption of these technical means [1, 3, 5].

The solution can be the use of so-called separate or two-phase technology for harvesting grain crops – mowing the bread mass into rolls consisting of a mown stem (using special reapers suitable for forming such an object), ripening the crop in the rolls under consideration and picking them up from the field with subsequent threshing [4, 6].

3 Results and discussion

Based on the research, patent search and analysis of the shortcomings of existing technical samples, it was decided to continue working in the direction of batch formation of rolls from mown stems. Reapers that use this technology form so – called portions that are joined when unloading-this configuration allows you to reduce the number of passes when further picking up the crop from the field [3-5, 8].

As a result, a reaper was developed that works on two-phase harvesting of grain crops by the method of forming a portion of a roll from mown stems, the parameters and operating modes of which take into account the minimization of grain losses and zonal features. The design of the machine in question is shown in figure 3. Intellectual property is protected by a patent of the Russian Federation for the invention. In addition to the standard components of the reaping machine, our design is equipped with a device for the formation of high stubble residues [1].

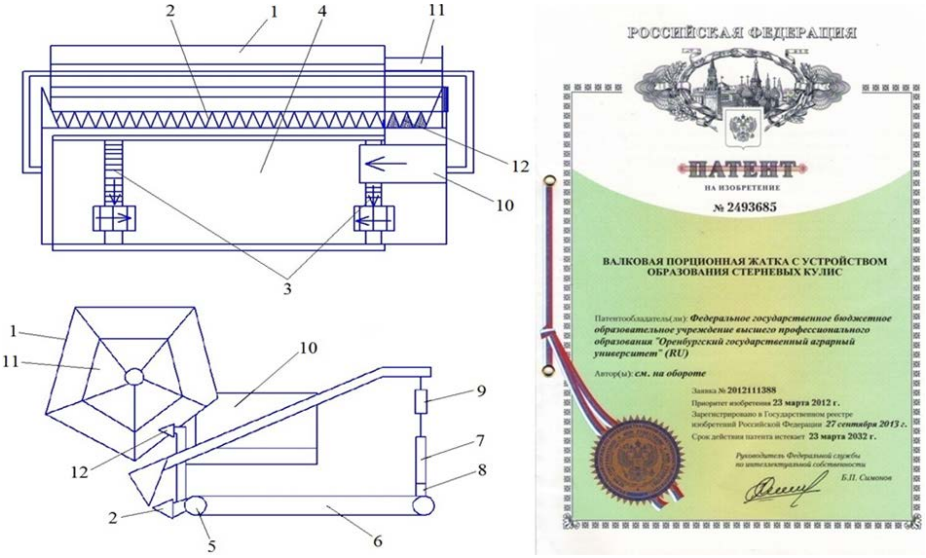

Fig. 3. Design scheme of a header for two-phase harvesting of grain crops, which operates on the principle of batch formation of a roll from cut stems, with a device for the formation of high stubble residues (intellectual property is confirmed by the patent of the Russian Federation No. 2493685):
1-the main device for bringing the stalks to the cutting apparatus; 2-the main cutting apparatus; 3-devices to prevent cut stems from getting under the wheels; 4-conveyor; 5-drive roller; 6-conveyor belt; 7-flap; 8-brushes; 9-flap lifting mechanism; 10-inclined tray; 11-the mechanism of the device for the formation of high stubble residues, which is a device for supplying stems to the cutting apparatus; 12-cutting apparatus that is part of the device for the formation of high stubble residues

After the mode of accumulation of the mown mass of stems when the band of the formed roll is reached on the field, a new portion is unloaded by raising the flap and increasing the speed of the conveyor. After unloading, a new accumulation begins [7].

The principle of operation of the device for the formation of high rod residues is as follows. Before starting work, the device for the formation of high stubble residues is adjusted based on the required height of the cut of the stems, so that only the ears are cut, and the stem remains uncut. When the Reaper is functioning, the main part of the crop collected in the traditional way (without the formation of high stubble residues) is cut and fed to the conveyor, and the device for the formation of high stubble residues cuts only the ears, which enter the chute and move along it to the conveyor belt, where they connect with

the flow of stems mown in the usual way [7]. As a result of research of the above device was obtained dependence, allowing to calculate the share of the area of the particular field that you want to leave a high stubble residue, for high-quality snow retention:

$$A = \frac{c\left[a(1-\frac{H_1}{H_{\max}})\right] - KH_2}{K(H_3 - H_2)} \cdot 100\% , \quad (1)$$

where c – the average density of the mutual arrangement of stems on the field, 1/m^2; a – the lowest moisture content of a meter of soil layer, kg; K – the amount of productive moisture per unit volume of snow, kg/m^3; H_1 – average height of stems on the field, m; H_2 – the height of the stubble, m; H_3 – the height of the high stubble residues, m; $H_{\max}$ – maximum height of stems on the territory of the field under consideration, m.

The graphical analysis of the joint operation of the device for feeding stems to cutting, which is part of the device for forming a strip of high stubble residues and the main device for feeding stems to cutting, allowed us to establish optimal operating ranges for the operation of the reaper under consideration with the simultaneous formation of high stubble residues. In particular, it was found that the radius of the device for feeding stems to cutting, which is part of the device for forming a strip of high stubble residues, for correct operation must fit in the range from 0.38 to 0.49 m; the optimal speed of rotation of each of the devices for supplying stems for cutting is 44-52 rpm; the circumferential speed of the slats included in the design of devices for bringing the stems to the cutting – 2.88-4.38 meters per second; the number of slats included in each of the devices for bringing the stems to the cutting, for the selected modes of operation – 5 pieces [1].

The study of the stability of snow cover on strips of high stubble residues included the determination of subsidence of the snow mass relative to the first measurement. The stability of the snow cover was estimated by the coefficient of its subsidence. The uniform distribution of the subsidence coefficient indicates that experimental strips of high stubble residues provide uniformity of snow retention, which is preserved during the snow lying and at the beginning of its melting.

4 Conclusions

Based on theoretical and experimental studies of the device for forming strips containing high stubble residues, the optimal mode and design parameters of its device for feeding stems to cutting are established: the optimal rotation speed is 44-52 rpm; the circumferential speed of the plank is 2.88-4.38 meters per second; a sufficient number of planks is 5 pieces, the radius is 0.38-0.49 meters.

The analysis of experimental and field studies has shown that the strips of high stubble residues formed during the operation of the Reaper for two-phase harvesting, which works on the principle of forming portions of the roll from the mown stems, which is equipped with a special device, ensure the uniformity of snow retention, which is preserved during the lying of snow and at the beginning of its melting. It was also found that the formed strips of high stubble residues provide accumulation of snow with a height of 0.45-0.50 meters, which increases the moisture reserves in the soil by the beginning of sowing by 1.8-2.3 times. Against the background of high stubble residues formed by the Reaper for two-phase harvesting, an increase in yield for the next season was obtained by an average of 26 %.

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