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LOSS MANAGEMENT WHEN HARVESTING GRAIN, LEGUME AND OILSEED CROPS

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Abstract

The article examines practical issues of harvesting the main cereal, legume and oilseed crops. The organization of technological processes of harvesting, their technical support, adjustment and preparation of equipment for harvesting are analyzed. The sources and mechanisms of seed losses during harvesting and methods of their prevention are considered. It has been found that farmers do not seek to minimize losses, but to achieve their acceptable optimal value.

Keywords: cereal crops, legume crops, corn, oilseed crops, harvesting, shedding, losses, management.

Formulation of the problem. It is known, that the assembly yield of grain and leguminous crops sums up the hard work of farmers. This process is influenced by a large number of factors that determine its dynamics, efficiency of use of equipment, the number, of losses, and the quality of harvested grain. The problem of efficiency has always been the focus. In modern conditions, only efficient production can be a guarantee of further development of the enterprise. This thesis applies to all industries and enterprises. But it is necessary to keep in mind the specific features that affect the formation of the appropriate level of efficiency in each of them. In particular, this applies to cereals, legumes, and cereals.

In recent years, domestic enterprises have significantly increased both production volumes and grain yields. This has allowed many producers not only to receive additional income but also to increase the profitability of production. At the same time, systemic problems continue to accumulate during grain harvesting. They are connected with untimely carrying out and stretching of terms of harvesting, absence on combines of the corresponding devices, their incorrect operation, regulation of working bodies which does not correspond to a condition of the collected bread, non-compliance of harvesting technology with harvesting conditions, low level of organization of harvesting works, for transportation of grain from the combine on teak, etc.

Analysis of researches and publications. The issues of research on the nature of losses and their management were widely covered in their works by domestic and foreign scientists, in particular: T. Beck, D. Voytiuk, S. Volvak, A. Gorbulin, I. Darren, H.-D. Kutzbach, O. Maltsev, V. Martsenyuk, V. Ogiychuk, A. Pugachev, S. Smolinsky, D. Shpaar, V. Shapovalov, and other scientists. Researchers provide graphical dependences of grain losses by combine harvesters and individual working bodies on the supply of bread mass and analysis of possible causes of losses [1, 2].

However, it should be noted that in terms of reducing grain losses during grain harvesting there are many unresolved issues, which are primarily related to the study of cost management issues and the solution of which requires further intensification of scientific research.

Formulation of aims of the article. The aim of the work is to determine the ways to manage losses on combine harvesters in the direct combining of major cereals and legumes.

Exposition of the basic material of research. Grain production is the basis for the development of flour and cereals, baking, brewing, feed, and other areas of the processing industry. Harvesting is the most important period in the technology of growing grain crops and the successful implementation of the annual cycle of work in the field, as well as the results of farming, depends on its successful implementation. The main requirement for this event is to harvest the entire crop without loss and maintain its high food and feed quality with minimal labor costs and funds, which can be achieved by clear planning and high organization of harvesting.

The experience of harvesting shows the constant presence of lost seeds after the passage of harvesting machines when threshing all crops. Depending on the culture, technique, weather, and local coincidence of

circumstances in a particular field, two or three sowing rates are lost.

This small proportion of lost seeds is not very noticeable at first glance, especially when a lot is produced, but with a low yield, loss prevention is a real way to increase production efficiency and profitability.

The main thing is to be able to quickly and in full take out grain from the field, to avoid its damage and losses from self-scattering or action of precipitations. Even temporary storage of grain in open-air barrels is unacceptable.

We think that grain crops can be harvested with the lowest losses and with the best quality, as well as with the lowest technical and post-harvest energy costs.

The main causes of grain losses during harvesting are:

- untimely determination of the beginning and duration of the period of harvesting of this or that culture;
- unsatisfactory maintenance of harvesting units, which causes long downtime;
- uneven field surface;
- thickened or liquefied crops;
- littering of the field;
- design defects of machines or their separate working bodies, violation of optimal technological regulations, etc.

Seed losses after ripening can be divided into natural and anthropogenic. Natural losses are difficult and sometimes impossible to manage. But they must be determined before harvesting to properly assess the losses of harvesters, and, consequently, to assess the adjustments of harvesters. The natural preconditions for seed loss include the biological properties of cultivated plants and weather.

Important biological properties of crops in terms of mechanized harvesting and possible losses include height, structure, and branching of the stem, location of fruits, the density of grasses, simultaneity and uniformity of seed maturation on a single plant and throughout the field, the tendency to lodging, tendency to shedding response to precipitation in the phase of full maturity. Such properties influence first of all a choice of a way of harvesting in general and at the direct combining influence a choice of a reaper.

Dry and quiet weather has always been and will be ideal for harvesting. In such conditions, the maximum productivity of harvesting machines and quality of seeds is reached and all negative factors of rain at harvest are neutralized.

All crops are vulnerable to moisture, but most of all - wheat, which can germinate in spikelets and cruciferous and legumes, because they crack pods and seeds fall out. Stable crops include barley, millet, sorghum.

While people do not know how to influence the weather perfectly, so they take various organizational measures due to weather forecasts.

The structure of anthropogenic factors covers the technical capabilities of combines, the organization of work, and the human factor.

D. Mogoryan and O. Maltsev draw their attention to the fact that different types of losses have different degrees of impact on grain yields, interacting with each other. According to the value of the correlation coefficient, they are distributed in the following order: agronomic losses (losses caused by a violation of the terms of sowing, cultivation and harvesting) - 41%, others (losses due to adverse climatic conditions) - 27%, agrotechnical (losses from violation of the technology of production of works during sowing, cultivation, and harvesting) - 13%, organizational (losses caused by underutilization of equipment, other resources, as well as shortages and theft of grain) - 12%, and biological losses (decline in grain mass during seed storage), which affects their sowing quality, when storing grain in currents and warehouses, leading to changes in both quality and quantity of grain) - 7%. Qualitative and quantitative indicators of the harvest directly depend on the technological equipment with which grain is loaded, unloaded, or transshipped. To ensure fast grain handling, with minimal losses and damage, the authors suggest using pneumatic grain conveyors. Due to the use of a cyclone at the outlet of the transport pipeline is the distribution of exhaust air and grain, while the grain is partially absorbed light impurities. The use of a pneumatic method of transportation reduces the percentage of crushed grain in the stream by an order of magnitude compared to mechanical transshipment. Also, the advantage of using a pneumatic conveyor is that due to the warm air the grain is dried [3].

The optimal time and possible flexibility for harvesting grain species and varieties depending on the ripening period, the properties of straw, the tendency to shedding, resistance to disease and germination, as well as the sensitivity of grains to mechanical damage.

In Ukraine, during the second half of the last century, two methods of harvesting grains and legumes were actively used - direct and separate combining.

In direct combining or single-phase harvesting, mowing and threshing occur simultaneously in one pass of the combine. In separate combining or two-phase harvesting, the vegetative mass was pre-mown and placed in tapes - rolls with special units - roller harvesters and dried for some time. Subsequently, the dried mass was selected and threshed by combines equipped with special pickers.

Under separate combining, mowing of crops began before full maturity. The seeds reached maturity in rolls. Thus, several effects were achieved. First, all the mown mass, including wet parts of plants, immature fruits, and weeds dried evenly, reducing the cost of threshing, cleaning, and subsequent drying of seeds. Secondly, there was no need for desiccation. Third, productivity on threshing increased, because the width of the capture of roller harvesters was 1.2 - 1.5 times greater than that of combines; harvesters could work longer during the day because the rollers were not afraid of dew. Two other reasons were related to the improvement of the quality of seeds of cereals, buckwheat and, especially, millet, and the second reason was the quality of straw, which in the USSR was completely harvested for livestock by the same combines.

In reality, the only way to harvest all crops on farms today is by direct combining. The method of two-phase harvesting is practically not used, except that

when growing millet. The corresponding set of equipment has become a great rarity.

This was facilitated by the arrival of combine harvesters from Europe and the United States, where only direct combining is used. High-performance and reliable combine harvesters of the best world brands have made it possible to harvest in a few days in optimal time.

Losses on the combine at direct threshing can be divided into four groups. The first group is the loss of the reaper. They are easy to notice visually and some of them can be quickly corrected with timely detection by simple adjustments.

The second group - losses after threshing from unmilled inflorescences and crushing seeds. The third group - separation losses. In modern combines, the loss of separation is detected and can be regulated by automation. The fourth group - losses due to depressurization of the combine. To check for leaks, the combine must stop at full load and stand still without reducing the engine speed until the thresher is completely released and separated from the treated mass. After that, the mechanisms are turned off, and inspect the surface of the field under the combine for seed shedding and correct the shortcomings found.

Direct combining is now the standard technology for harvesting grain. Its advantages: independence from weather conditions, higher quality of threshing, lower costs of energy and labor, and lower cost of production.

Modern self-propelled combines have a reaper, a threshing machine, a straw shaker in many varieties, a straw cleaner, and a shredder.

The harvester cuts the stems and transports them to the threshing machine. Uniform transportation is provided by a rotating reel with controlled spring teeth. Its speed and height are adjusted during operation. This ensures, at different lengths of stalks or spikelets that have fallen out, a continuous, uniform supply of bread mass to the transport auger. As a rule, the speed of rotation of the reel is slightly higher than the speed of the combine, which prevents the loss of knocked out of the ears of grain. Proper installation of stem lifts relative to the soil surface is very important for quality operation. The height of the cutting device is also adjustable from the control panel.

Loss of grain behind the combine harvester was determined by applying a frame of 0.5x0.5 m in places that are free from the roll of straw after the passage of the combine. Free grain, grain from cut and uncut ears were collected within the frame (grain was separated from ears) and weighed. The research results were processed by the methods of mathematical statistics [4, 5] and with the use of applied computer programs and are presented in graphical form (Fig. 1).

When analyzing the results of experimental studies, it was found that with increasing grain yield, straw and stalk weed due to increased feed in the grain mass of straw and weed stalks will increase the amount of grain loss behind the combine harvester (Fig. 1 a, b, c). With an increase in the decay of the stalk within 2.87… 7.55% there will be a slight increase in grain losses, and with a decay of 21.64% due to an increase in the number of uncut stems with grain in the ear, the grain loss will reach 2.29 g / m2 (Fig. 1 d). The increase in the moisture content of stalks from 12.8 to 27.6%, which is typical for harvesting conditions, will lead to a slight variation in the amount of grain loss in the range of 0.24… 0.36 g / m^2 (Fig. 1 e).

An analysis of the distribution of grain losses in the combine harvester on its main types was also carried out: free grain, grain in the ear of the cut stalk, and grain in the ear of the uncut stalk. As a result of research, it was found that the largest share of grain losses behind the combine harvester in the form of free grain, and other types of losses - 2.0… 2.5 times less than the number of lost free grain. But in areas with increased stalk decay, the amount of free grain and grain in the ear of the uncut stalk is almost the same, which indicates the need for additional settings of the harvester when working with a fallen stalk.

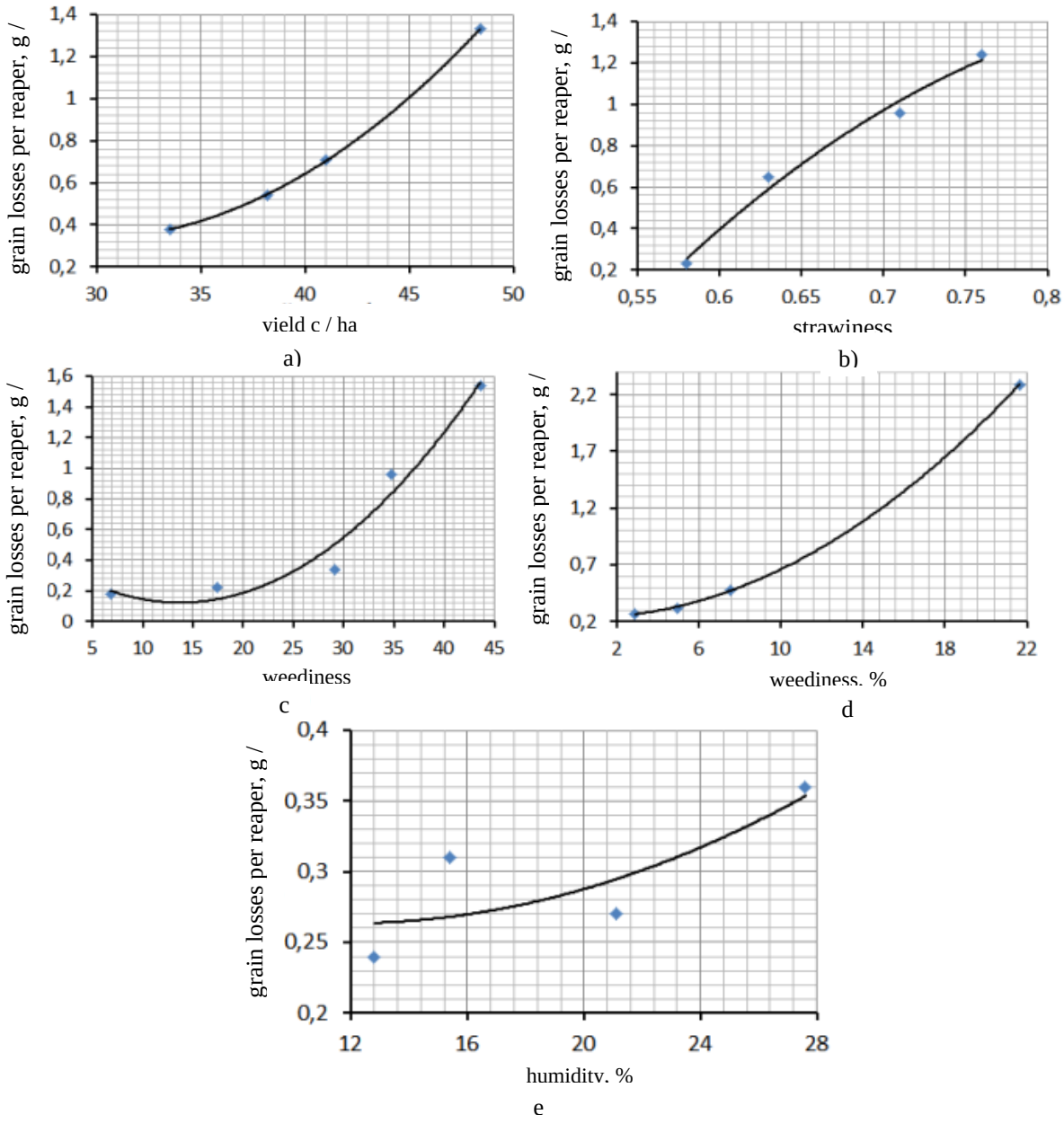

Fig. 1. Graphs of the dependence of grain losses on the reaper of the combine harvester on agrobiological parameters of grain crops: a) yield of grain crops; b) straw stalk; c) weed stalk; d) fallen stems; e) moisture stem
Source: [4, 5, 6]

The threshing machine consists of a threshing drum (length - 1,2-1,7 m) with the corrugated laths of various forms and drumming attached to it between which grains are separated under the influence of blows and friction of spikelets. Most grains fall through the openings of the sieve drum and are transported to the cleaner. Part of the grain together with the remains is thrown out through the outlet of the drum. It can be separated from the straw only with a straw shaker. There are tangential and axial, or axial-rotor threshers. Most types of combines have a tangential threshing machine. In axial threshers, the bread mass is transported by drumming parallel to the axis of the drum. Whereas in tangential threshers this mass is transported only once on the grain-separating surface of the drum, in axial - up to 8 times. Grain separation by drumming is achieved in the latter better - 95-100%, in the tangential threshing machine - 70-85%, so it combines with the axial threshing machine there are no straw shakers.

In wet conditions, combines with axial threshers have a relatively strong decrease in productivity. The threshing machine is adjusted by changing the speed of the threshing drum and the distance between the drum and the drum. The distance should decrease from the entrance to the exit. The shorter the distance and the higher the speed of rotation of the drum, the better the grain is threshed, and at the same time its crushing increases. Therefore, a compromise solution is required when choosing the speed of the drum from 25-33 m/s. The wetter the straw, the smaller the distance between the drum and the drum, and the higher the drum speed [7].

The straw shaker combines with the tangential threshing device as a result of repeated shaking separates residual grain from the straw and at the same time transports straw to the end of the combine. The straw

walker consists of 4-8 keyboard chords, the surface of which is sieve-shaped. With the help of cranks, they vibrate. The straw is transported to the storage or shredder, and the grain and other small particles through the holes of the straw walker fall on the cleaner. The larger the surface of the straw walker, the better the grain separation. In modern combines, it is 1-1.5 m^2/m width of the combine. Separation of grain also depends on the loosening of the straw layer on the straw shaker, on which the loosening teeth are installed.

The treatment plant separates chaff, hollow spikelets, straw fragments, and other small particles from the grain. It consists of two sieves (upper and lower louver sieves with a total area of 4 to 6.5 m^2), through which the fan blows airflow.

The passage through the upper sieve is regulated so that the floor, straw fragments, and empty ears are delayed and airflow is carried out from the rear of the combine. Grains and spikelets fall on the lower sieve. It is regulated by passing only the grains, which are transported by the grain auger to the hopper. All threshed parts, which are not removed by airflow and do not pass through the lower sieve, fall at the end of the sieve on the rotary auger. With proper regulation of the sieves and airflow, only unthreshed spikelets or their parts get there. They are transferred to the threshing machine by a rotary elevator. Too small holes in the lower sieve lead to re-threshing of the grain, resulting in an increased risk of crushing. In case of insufficient airflow, the rotary elevator is overloaded with light particles of straw and spikelets, which can lead to clogging of the system.

Straw shredder. Straw can either be stacked or shredded in a combine and distributed in the field. The spreading width can be nine meters or more. Uniform distribution of straw is of particular importance during tillage and direct sowing [8].

The productivity of combines and the quality of their threshing are constantly improved by improving the threshing, separating, and cleaning systems.

During the operation of the combine, there are losses before harvest, threshing, straw shaking, and cleaning.

Losses during rejuvenation can be estimated from unthreshed ears behind the combine. The grain that falls behind the combine loses its straw shaker or treatment plant. To minimize the overall loss, you need to listen to even minor losses during threshing.

Varieties of modern selection with a high yield index allow direct combining with greater productivity in area and reduction of grain losses to 1.5% or less. Harvesting losses strongly depend on the resistance of the variety to lodging.

To determine the losses during harvesting, place a test bowl measuring 1.0×0.25 m in the stem before the passage of the combine. The combine goes on, and when the bowl is under it between the front and rear wheels, it is taken out and counted the grains that are left there.

Losses from unthreshed are determined by unthreshed spikelets in straw rolls. Remove 50 spikelets from the straw roll, check for the rest of the grain and compare the results with the allowable limit parameters. Such measurements are repeated three times.

Table 1

Approximately permissible parameters of losses from underhammer according to D. Shpaara

Indicators	Barley	Wheat	Rye	Oat
Grains left in 50 ears				
Harvesting conditions from good to medium	3-7	5-10	1-15	6-12
Poor harvesting conditions	7-15	10-16	15-25	12-18

Source: [9]

Losses behind the straw shaker and during cleaning are determined using a tray, which is placed under the falling roll of straw behind the combine. The straw is shaken over the test tray, the grain present in it is counted and the results are compared with the available limit parameters. The measurements are repeated three times.

Particular attention should be paid to maintaining the quality of the grain, especially malting barley and intended for sowing. Damage to grains during threshing can be:

- macroscopically visible, such as longitudinal or transverse chipping of the grain, crushing, crushing, broken or broken germs;
- microscopically visible, such as thin cracks in the epidermis, embryo, and endosperm. Wheat is more sensitive to threshing than barley.

Germination cannot be determined immediately after threshing, even if the dormancy period of the grain has already ended, as damage during harvesting stimulates grain germination, such determinations give distorted results. Later, the germination rate decreases or even completely lose the ability to germinate in some parts of the grains.

The lost seeds germinate and it becomes clear that the bulk of the losses after the passage of the combine is concentrated in a narrow strip of field between the wheels of the combine.

Fig. 2. Seedlings of wheat grain lost behind the reaper

Source: generated by the author

Fig. 3. Seedlings of wheat grain lost behind the thresher

Source: generated by the author

Such properties influence first of all a choice of a way of harvesting in general and at the direct combining influence a choice of a reaper. For example, wheat, barley, oats, rye are harvested with a reaper of a classical complete set.

For harvesting rapeseed use a prefix with an elongated table and with active field dividers, for harvesting soybeans use reapers with a flexible knife, for harvesting openers and corn there are specialized reapers.

When combining directly, it is very important to correctly determine the optimal harvesting time. It is advisable to begin the inspection of crops when they pass into the phase of yellow or milk-wax ripeness. It is in this phase that you can see the difference in maturity, which is no longer noticeable later. Observations should be continued at two-day intervals. Depending on the condition of the crops determine the order of harvesting.

Harvest ripening corresponds, depending on the tendency of varieties to the fragility of spikelets and shedding of grains, varietal timing of the phases of full ripeness of grain.

For optimal threshing of grain it is necessary to be guided by the following indicators:

- grain moisture - not more than 18%;
- the grain should have a typical color and normal size for this species, the surface - slightly wrinkled;
- the grain is hard and cracks when bitten;
- the grains can be completely removed from the spikelets, but they are still so firm that they do not fall out without the use of external force;
- the yellow color of mature straw turns into a dirty gray color;
- nodes stalked brown and solid;

- barley straw is easily broken at the top of the stem;
- rye straw breaks down into small pieces during rotation;
- wheat stalks are often easier to break at their base.

With the right choice of harvesting time, losses are minimal [9].

An eosin test can be used to predetermine the degree of maturity and harvest time. To do this, prepare a 1% solution of eosin. Choose 20 productive stems, cut them at a height of 20-30 cm from the ear, and put them for 8-24 hours in the liquid. The degree of color is used to evaluate the previous onset of harvest ripeness.

If most of the spikelets have been stained after the required exposure, the harvesting period of this crop will be approximately 8-10 days. If the stems were painted to the base of the ear, it means that in the coming days trial threshing is possible to more accurately determine the time of harvest. In the same case, when even on the stems there is no red color, you should start harvesting immediately.

Climatic and weather conditions have a decisive influence on the harvest. Harvesting by combines should be organized in such a way that, if possible, bypass technical drying. The financial costs of drying are usually much higher than the financial revenue when using combines in suboptimal conditions. Special attention should be paid to humidity, dew formation, and the transition of moisture to the grain.

At humidity 81-100% of combining is not carried out, at 51-80% - optimal harvesting conditions, at 50-31% - possible harvesting with proper installation of the combine, 30% and below - harvesting in gentle mode with the highest speed of the combine.

During the strong formation of dew, the increase in grain moisture can reach up to 3.3%, and in its absence - up to 0.8%.

Different tiers of grain stalk density dry at different speeds. Depending on the terrain, the moisture content of the grain varies greatly even at a relatively short distance, which should also be taken into account when taking samples to determine the humidity and organizing the work of combines.

It is necessary to control losses before harvest. This is especially true for those crops and their varieties that are prone to breaking ears (winter and spring barley), shedding of grain (oats, some early varieties of winter wheat), lodging (rye, winter barley), or germination (rye, triticale) [10].

It is necessary to carry out a check of threshing 1-2 days before the beginning of harvesting for the correct decision on the use of combines and the organization of work. When determining the sequence of harvesting by harvesters should be based on the degree of urgency of harvesting, which is affected by the harvesting area, the number of harvesters, risk of loss, weather conditions, the urgency of further fieldwork, and grain use. Features of certain types of grain should be taken into account during harvesting.

Winter barley is a crop that is difficult to harvest. Harvesting by harvesters is complicated by the fragility of spikelets, the tendency to lie down, the short optimal threshing time, and hard thorns. Crops ripen, as a rule, very unevenly. The beginning of the harvesting period is considered to be the stage when the fragility of the classes is still weak, the awns are already in a mature state but break only during threshing.

Spring barley is an ideal crop for harvesting with a combine. Terms of assembly allow realizing the big productivity of the equipment.

Brewing barley requires full ripening. Collect it when the first broken ears appear. Thrifty threshing is important.

Wheat is also very well suited for single-phase combine harvesting. Ripening occurs more evenly than in barley.

Rye is quite difficult to harvest with a combine. Rye is harvested last (after wheat), and there is a problem with shedding. Also, with improper regulation of growth and significant rainfall, rye can fall out, which significantly complicates harvesting and leads to loss of yield and quality. When harvesting rye for silage, first of all, an error is made in determining the optimal phase for mowing and its duration. To obtain high-quality silage, the mass should lie as little as possible on the field, so you need to quickly spread the roll of freshly mown mass on the field because in the first 2 hours the largest amount of water from plants is lost.

Triticale is similar to rye in its suitability for combined harvesting.

Oats, due to their short harvest time, uneven straw ripening, and high propensity to fall, are also difficult to harvest.

In addition to direct grain losses, there are side effects. These include a decrease in sowing and baking qualities of grain, which may occur due to its mechanical damage. In this case, the respiratory process increases, the development of microorganisms, mites, and other pests, which is one of the causes of self-heating. Therefore, during the entry of wet grain, it is necessary to dry it or temporarily preserve it. The grain temperature should be checked at regular intervals. Raw grain can be stored for only a few days, provided it is preserved by cold and other means. With regard to pests of grain stocks, then in compliance with current recommendations and active control measures, their impact can be eliminated. If these causes are not eliminated in time, the grain may become completely unusable. The greatest damage to the grain during harvesting by harvesters occurs during threshing. At postharvest processing, storage, and sowing by seeders mechanical damage, in comparison with threshing, is insignificant.

Ingrain production, harvesting in agro-technical terms (7-12 days) and thus eliminating significant grain losses, deteriorating its quality, and minimizing costs remain an urgent problem. Loss of grain (winter wheat, barley) from shedding 20 days after full maturity is from 12 to 40% [11].

Table 2

Total grain losses from the start date of harvest after full ripeness,%

Culture	The number of days from the onset of full maturity			
	0-5	6-10	11-15	16-20
1	2	3	4	5
Favorable harvesting conditions				
Winter wheat	0,75	2,93	5,10	8,28
Wheat	1,09	4,79	8,49	12,19
Barley	1,07	2,10	4,10	8,01
Oat	2,32	6,33	9,60	12,22
Adverse harvesting conditions				
Winter wheat	3,75	14,63	25,20	36,38
Wheat	5,47	23,96	42,45	60,94
Barley	2,49	9,87	21,77	40,33
Oat	11,96	29,07	46,19	63,30

Source: [11]

Therefore, it is most appropriate to harvest bread in the period due to agronomic terms. Ensuring these conditions is possible with the help of breeders who could invent new varieties of crops, with a lower tendency to shedding, or through clearing reapers that provide the necessary quality indicators.

Therefore, the reduction of mechanical damage to grain during threshing has the same economic importance as the prevention of direct losses. In order to prevent losses in a timely manner, it is necessary to determine the reasons for which they occur and in what sequence, as well as to adjust the mechanisms of machines during harvesting, cleaning, and sorting of grain.

It is always difficult to enter the field after a rapeseed harvest - the ground is covered with seeds. The real figures are 200-600 kg/ha. So I want to take a powerful vacuum cleaner and assemble it. However, all that is really possible to do today is to reduce the number of losses.

There are several reasons for significant rapeseed losses during harvesting. First, it is an uneven maturation. The pods of the upper tiers begin to open and lose seeds, while the lower ones are not yet ready for harvest. Also strongly provoke raindrops. Pods that get wet, then dry, begin to open quickly. Under such conditions, chemical desiccation is used, the beginning of which must coincide with the blackening of the first seeds, in addition, the seeds in the middle tier of the main stem are reddish-brown or dark brown, the pods are yellowish. Harvesting begins 7-10 days after treatment.

The use of desiccation allows you to perform harvesting in the optimal time, in addition, the harvesting period can be significantly increased. This significantly smoothes peak loads, reduces the required number of equipment and personnel. Desiccants also reduce the moisture content of the seeds and, accordingly, reduce the cost of drying.

Rapeseed harvesting is used separately in unstable weather conditions, the impossibility of drying the harvested grain and significant weeds: first, the rapeseed is mown into mows, where it reaches, and only then threshed. The advantages of this method are the reduction of seed shedding due to wind, precipitation, and uneven ripening. However, the mechanical impact on the plant's increases, and if you start the mower late, you can, conversely, increase the number of losses.

V. Ogiychuk claims that the next cause of losses is the absence or improper use of equipment - reapers, threshing systems, and separation of combines. It is established that under certain conditions the level of crop losses per reaper (free grain and grain in cut and uncut stems) maybe 10-20 times higher than the initial requirements - 0.5-1.5%, especially when mowing fallen crops. The use of rapeseed tables or variable width headers together with vertical side knives partially reduces losses. Further development of technology has led to the creation of a pneumatic support system that helps to "blow" the seeds of falling rapeseed. This system increases the cost of rapeseed equipment of the combine but pays off very quickly.

Due to the fact that rapeseed is small and light, it moves easily with plant debris and airflow. Therefore, the settings of the combine should not be neglected - it is due to errors with the setting that a significant proportion of seeds is lost [12].

To understand the situation with losses, they must first be counted. Due to the small size and dark color of rapeseed, measuring losses is a rather complex process. Seeds that fall to the ground are difficult to see and difficult to collect and count. Therefore, few people want to do this slow work - there will still be losses, and what exactly - it is better not to know. On the other hand, calculating losses may prompt certain actions to reduce them. For example, if the total amount of rapeseed lost is $ 100 per hectare, then by halving the loss, the farmer will receive $ 50 additional income. Therefore, business owners must motivate agronomists to calculate losses, find the causes, and eliminate them.

Several measurements should be made to determine the size and sources of losses. First of all, it is necessary to assess the presence of natural losses, ie received before the contact of plants with the combine. To do this, carefully enter the field and in small areas try to count the number of grains on the ground. Of course, in an array of intertwined branches, it is difficult to do, but it should be remembered that this calculation will provide an understanding of the source of losses. It is possible that the combine or harvester does not create problems, and the losses are mainly due to weather conditions (heavy rain, hail, wind) and the condition of the plants themselves.

The next step is to calculate the losses separately for the reaper and combine. To do this, stop the combine abruptly during harvesting, select a few areas between the header and the rear wheels, and count the amount of seed scattered. The same should be done in several areas behind the combine - the task is not easy, because looking for rapeseed under a layer of debris is extremely difficult. To simplify this work, foreign manufacturers offer a special tray on electromagnetic mounts, which can be installed on any combine. At the signal from the remote control, the magnets are turned off, the tray falls on the stubble and is filled with chaff, plant debris, and seeds that have not been separated from the plant mass. Thus, it is possible to calculate losses on the combine much faster, without going through a heap of the remains, a floor, and soil. All three calculations allow us to see how many losses there were in the field, how much the harvester "made", and how much - the threshing and separation system.

Measurements of losses should be made daily. Even during the day, the harvesting conditions may change several times and require adjustment of the combined settings. Many will say that this is impossible, but if you motivate the operator, he will do it. It is clear that all employees try to make the maximum of hectares, and the quality of work performed is taken into account only when necessary, when forced by management. Therefore, it is necessary to take such organizational measures so that productivity does not suffer, and at the same time losses are reduced.

If natural losses are difficult to regulate and sometimes impossible, the situation with technology is much simpler. For example, grain losses behind the reaper are controlled by the speed of the combine, the speed of rotation of the reel, the cutting height, and the angle of the reaper. But usually, no tangible changes can be achieved - except that the initial settings were too different from those recommended for rapeseed harvesting.

The main sources of losses in the combine are threshing and separation systems. This is where significant results can be achieved. To do this, each parameter should be changed once, and after each adjustment to calculate the actual losses. The settings of the combine, which affect the number of losses during harvesting, include rotor speed, the gap between the rotor and the drum, the speed of the air fan, the holes of the upper and lower screens [12].

Modern combines with proper setup almost do not allow losses. But losses are still formed due to the desire to work with maximum productivity. However, the operating parameters of the combine with maximum productivity and the parameters of its operation with minimum losses do not match. If there are no losses at all, but the productivity of the combine decreases, then the cost of harvesting will increase, the duration of work will be stretched. The field may be exposed to rain, and these factors could potentially lead to a trail of seed quality problems and even more losses. Therefore, farmers do not strive for minimal losses, but for their certain optimal value. The situation is exacerbated when the farmer does not have his own combine and has to hire equipment from the outside.

Dry rape threshes well, but just as well it crumbles at the slightest movement of the plant. Therefore, rapeseed should not be expected to dry out, as this will lead to significant losses. In addition, threshing too dry rape leads to the appearance on the sieves of a large number of small residues - the plant mass in the rotor "grinds", and a certain part of it together with the grain enters the separation system. As a result, the sieves are overloaded, the grain does not have time to pass through the holes and leaves the combine with the garbage.

The too high moisture content of rapeseed also does not guarantee losses: in this case, a significant proportion of the crop is not threshed and leaves the combine with crop residues. Rapeseed grains stick to straw or pods, which makes it impossible to separate them in the rotor or drum.

American farmer John Scotney measured losses on his Case 8120 combine using a Bushel Plus pallet. The average yield of rapeseed was about 25 kg/ha, in addition, initial measurements showed a loss of about 180 kg / ha. Changing the settings of the combine has reduced losses to 80 kg/ha. Accordingly, from an area of 1,200 hectares, the farmer received an additional 120 tons of rapeseed.

Another farmer, Darren Ivers, reduced losses by 214 kg/ha just by adjusting the fan speed. On his John Deere S680 combine, the fan initially ran at 800 rp/m, with a loss of 286 kg/ha. When the fan speed was reduced to 620 rp/m, the losses were reduced to 91 kg/ha, but too much debris began to enter the hopper. It was clear that the airflow needed to be increased so set the fan speed to 750 rp/m. The calculation showed that only 72 kg/ha is lost in such languages. Therefore, the farmer received 100 tons more per 500 hectares. Therefore, the time and effort was not wasted.

The main criterion for the beginning of the sunflower harvest is the moisture content of the seeds, which depends on the ripening phase and weather conditions. Pouring sunflower seeds ends 34-40 days after the end of mass flowering sowing when the plant has a humidity of about 25-30%.

The maturity of the sunflower is determined by the color of the basket. I would like to draw your attention to the fact that there are three degrees of maturity:

- yellow - leaves and the back of the basket have a lemon-yellow color, the humidity of the basket in the range of 85-88%, seed moisture - 30-40%;
- brown - the basket has a dark brown color, the humidity of the basket is 39.5-50%, seeds - 10-12%;
- complete - drying of the plant, humidity of the basket - 19-20%, seeds - 7-10%.

The optimal harvest time occurs when 20-25% of all crops have a yellow and yellow-brown color, and other plants - dry, brown.

When determining the duration of harvesting, the cost of seed losses per unit area, and the minimum cost should be taken into account. An important condition for harvesting without significant losses and mechanical damage is the correct equipment, as well as careful preparation of harvesting equipment. It must be done in advance, otherwise, there is a risk of downtime. Without

the use of modern combines for harvesting, which provide careful threshing, highly efficient separation and quality cleaning, crop losses can reach 20-25%.

Among the requirements for reapers farmers call:

- the ability to operate the combine without reducing productivity in weed-infested fields (the harvester should collect only the sunflower heads clean and dry);
- speed of work of equipment not less than 8 km/h;
- the ability to harvest sunflowers both along and across the field;
- minimal losses;
- reliability and ease of operation of the reaper.

The preservation of the crop is affected by the correct choice of the reaper. It is recommended to use special or universal reapers. You can use adapters, special attachments (sunflower attachments) for grain harvesters.

Fig. 4. Loss of sunflower baskets at harvest
Source: generated by the author

To harvest low-growing varieties of sunflower and hybrids that lie due to weather conditions, you should use low-cutters. They will reduce losses by 2-7 times. This Nardi SunStorm reaper is offered by **ABA Astra** [13].

The following criteria are taken into account when choosing this unit:

- it can be with or without a stem shredder. Using it will reduce productivity and increase fuel consumption during harvesting, but will save on mulching, ie on one technological operation;
- remember that the same reaper cannot be used with all combined harvesters, because different machines have different in size and design inclined chambers with which it connects;
- in the case of a row reaper: the number of rows will depend on the number of rows of the drill used to sow the crop, ie these numbers must be multiples or use precision farming systems at the time of sowing. There is no difference in continuous cutters.

The ASTRA agro-building alliance offers customers continuous Italian-made reapers under the Nardi brand. **Nardi harvesting** is a brand of the family company Pegaso S.r.l. (owned and operated by the Nardi family). The plant is located in northeastern Italy. The company has been operating in the market since 1980, and today it is a well-known brand in countries from Europe to Kazakhstan, North America, Africa, etc. due to the quality and reliability of its products.

The company uses two plots with a total area of about 6,000 square meters. m and employs 50 people. Thanks to experience, the design and production processes are 100% performed in factories in Italy, starting with raw materials.

Quality material for production is purchased from suppliers in northern Italy. Before starting the production of any new product, the company collects feedback from combine harvesters, farmers, and importers and takes them into account in production.

The research and development department uses the latest versions of 3D-engineering software. The metal-design department produces structural parts with the most modern technical and precise equipment.

The variety of models gives the chance to pick up a reaper under the combination of any power. Proper selection guarantees efficient and cost-effective operation.

Advantages of NARDI continuous-cut sunflower headers:

- the special form of dividers provides their high permeability, and the strong design promotes avoidance of vibration and gives effective collecting of the fallen weight;

- the adjustable protective cover of a reel allows to make the cut as close as possible to a sunflower basket to minimize receipt of a part of a stalk and leaves in working bodies of the combine;
- the Sunstorm cutting device is developed for a cut of a thick stalk. A clean and efficient cut of sunflower baskets is guaranteed by the high speed of the knife - more than 700 slices per minute;
- the reaper auger is equipped with a torque limiter, and the cutting device is set in motion through a belt-drive, which guarantees their protection against breakage in the event of solid objects;
- cutting machine, auger, reel rotate synchronously;
- set for harvesting fallen sunflower;
- a patented brush system is available as an option for Nardi rowless headers. It reduces vibration and loss, is easy to replace/maintain, and has a long service life;
- the metal mesh completely covers the auger. This ensures the safety and helps to avoid the release of flowers even at high speeds;
- the shield helps the sunflower baskets reach the blades in the right position to be cut, leaving the stalks in the field (cleaner harvest and less strain on the threshing and cleaning system for the combine). The position can be changed hydraulically or mechanically [13].

It makes sense to invest in professional, reliable equipment, and not lose money by buying cheaper, unreliable low-quality reapers!

Crops of soya harvested direct combine harvesting. To do this, re-equip the combine - set the cutting device to the lowest possible cut and reduce the speed of the threshing drum to 500-700 rpm. At low seed moisture (8-12%) the drum speed should be minimal. For high-quality cleaning, it is necessary to pay attention to the adjustment of a technological backlash between a drum and a drum, adjustment of system of clearing, and a reel.

To increase the amount of harvest and the efficiency of combines, the FLEX soybean harvesting device is used - it allows you to quickly convert a conventional reaper to harvest legumes, soybeans, peas. Special technology completely copies the relief of the soil, cuts the plants at a height of 26 mm. The equipment moves on the special sliders providing a deflection of equipment on 10 cm and optimum adherence to a soil surface.

Fig. 5. Loss of soybeans on a classic reaper

Source: generated by the author

Direct combining begins when the grain reaches economic maturity and its moisture content is within 16–18%, when the leaves have fallen off, the stems and beans are brown, dry, the grain has a normal color characteristic of a certain variety, and is separated from the bean leaves. Under adverse weather conditions during the harvest period, the grain is forced to be threshed at high humidity (18–22%), providing for urgent cleaning and drying of seed material. In the case of harvesting soybeans with high humidity, the speed of rotation of the drum is increased by 10-12%.

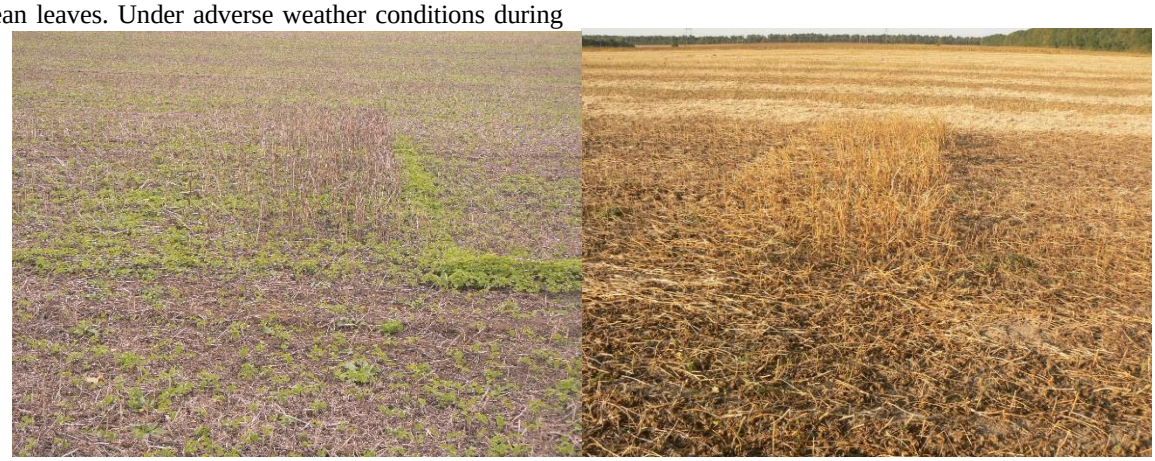

Fig. 6. Total soybean losses after reaper failure

Source: generated by the author

Gap clearances during threshing of dry soybeans at the inlet are 30-38 mm, at the outlet - 18-28 mm. If the mass is wet, they are reduced to 26-34 and 12-20 mm, respectively.

During harvesting, the degree of seed injury should not be controlled, which should not exceed 1%. To do this, threshing should be carried out in the optimal time at low speeds. The drum speed and the clearances of the combined threshing units must be adjusted accordingly.

Soybeans are a very hygroscopic crop, easily absorbing moisture - vapor from the air and liquid from precipitation. Dew, fog, precipitation lead to hydration of the vegetative mass of beans and seeds, in sunny weather, they dry quickly. This should be taken into account when harvesting soybean seed plots.

Stagnation with the harvesting of soybean seed crops is not acceptable at all - sowing qualities of seeds are reduced, the amount of hard (with a stone shell) seeds increases, pathogens accumulate on the seeds.

Desiccants are used to accelerate the ripening of late-ripening varieties and in the cold years and medium-ripening. Soybeans are sprayed in the early browning phase of the lower and middle tier beans. Desiccation makes it possible to start harvesting grain 10-12 days earlier. The optimal time for processing soybean crops with desiccants occurs at a moisture content of 45-50% and browning of the beans of the lower and middle tiers. In the case of earlier desiccation (at a humidity of 60–65%) the yield decreases sharply - by 2–3 h/ha. However, this method should be considered as insurance. It is best to sow varieties that use the entire growing season and reliably reach full maturity.

Producers should check the losses in the reaper because under normal conditions 80% of all crop losses fall on the reaper. However, if soybeans are harvested late, hard stems and pods are likely to increase threshing and cleaning losses. Therefore, checking for losses on the combine is also important. For every four beans per square foot that remain on the ground, one bushel of crop per acre is lost. Beans with high humidity should be dried immediately after harvesting.

If the weather does not improve, some growers may consider leaving soybeans in the field in the winter and harvesting them in the spring. This is a risky practice. Snow can nail plants to the ground, which will make harvesting very difficult. The risk of seed damage by the fungus also increases with delayed harvesting. The presence of the fungus is indicated by linear rows of black spots on the stem. If you see these signs and infected pods, then there is a chance of seed damage. The good news is that the risk of sprouting soybeans in the pods is low if the pods are whole.

Growers who harvest soybeans in November each year should consider using earlier varieties of soybeans that ripen earlier.

Fig. 7. Loss of soybeans during threshing in conditions of high humidity

Source: generated by the author

Fig. 8. Soybean seedlings from losses after threshing

Source: generated by the author

As practice shows, harvesting of corn occurs in the autumn period with a high probability of precipitation, when harvesting begins at a humidity of 25-30%. At the same time, up to 25% of the

corn crop can come with a high level of humidity. Leaving corn in the field for drying, there is a risk of its lodging and deterioration of phytosanitary conditions. The probability of developing negative microbiological processes and lesions of bacterial and fungal diseases is quite high. And the problem of the negative effects of mycotoxins is very acute. As a result, at the end of the season, the quality of corn often deteriorates.

In the total dry above-ground mass of corn, leaves, stems, fans, rods (with a leg) and wrappers account for an average of -60%, and grain - about -40%. Thus in grain with cores on the last, it is necessary to -18%. With the harvest of corn, 70-73% of biomass is alienated, and the number of residues is less than other crops.

Cobs of low-growing hybrids of corn are placed 25-45 cm from the soil surface, tall - more than 60 cm. Placing cobs at a height of less than 30 cm complicates harvesting and increases losses. For mechanized harvesting of corn for grain, it is better to use precocious hybrids with strong stems and small leaf mass, characterized by friendly ripening, cobs should be vertically oriented with wrappers that are easily separated.

Fig. 9. Loss of corn due to improper adjustment of the threshing machine

Source: generated by the author

1% of logistics losses is adequate to 10% of production losses. In this sense, the number of transshipments of corn should be minimized, and logistics should be well thought out and actively

used [14].

Conclusions. Thus, the results of field experiments confirmed the previously obtained data that machine operators and farm specialists do not sufficiently possess the features of setting up modern grain harvesting equipment, do not fully use its technical capabilities, which causes great material damage to farms due to increased grain losses during grain harvesting. ear crops. Farmers do not strive for minimal losses, but for their certain optimal value. The situation is exacerbated when the farmer does not have his own combine and has to hire equipment from the outside.

It is established that the main grain losses occur behind the threshers of combine harvesters and exceed the limits set by the current agronomic requirements. Reserves for increasing grain harvests in farms consist of the optimal adjustment of combine harvesters and approximate points of the value of optimal losses to the minimum values.

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