

## ECONOMICAL TECHNOLOGY OF RAPE SEED HARVEST

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Rape seeds as a raw material for fat industry, have been remarkably changed lately referring to both chemical composition, and physical properties. New bi-zero rape varieties greatly differ from the previous high-erucic ones. Farmers focused on the raw material's quality improvement, thus often neglecting other traits, for instance the silique's susceptibility to cracking. It appeared that improved varieties were several times more susceptible and very easily shattered the seeds. Therefore, the harvested crop differs significantly from the biological one. Besides, the seeds of these varieties show higher susceptibility to injuries. As an effect, rape producers applying traditional harvest technology suffer great quantitative losses of seeds, and fat industry often achieves raw material exceeding the standard norms referring to mechanical damages, which univocally diminish its quality.

Wide-range and systematic investigations upon rape physical quality were begun a relatively short time ago – at the end of 70's. The Institute of Agrophysics in Lublin where the problem was discussed in detail, should be cited as an initiator and executor of the research. Just preliminary tests of rape's physical properties, namely silique's susceptibility to cracking, revealed unexpected results. It appeared that they contradicted the well-known knowledge from handbooks on the necessity of rape harvest after rainfall, because then there would be the least quantitative seed losses. However, results of mass studies univocally pointed out that when rape achieves full maturity, every seed wetting causes sudden decrease of their resistance to cracking, and thus easier seed shedding during bad weather and harvest. Numerous tests and measurements confirmed such dependence under production conditions. Therefore, investigations directed towards an adaptation of existing agricultural devices to specific traits of new rape varieties in order to maximally reduce quantitative seed losses during maturation and harvest and apply these working parameters in all combine-harvester's assemblies, were undertaken. Furthermore, the reasons for seed injuries during after-harvest processing were searched for.

## AGROPHYSICAL BASIS FOR THE NEW TECHNOLOGY VARIETY FEATURES

Improved winter rape varieties being the source of high-quality oil and ground grain with decreased hazardous substance contents have lately appeared in our country. They are double-improved varieties (bi-zero), i.e. containing the minimum level of erucic acid and much diminished content of sulfur compounds (glucozinolans) in seeds.

Though 3-6 varieties were registered and permitted for cultivation in 1987-1991, there were 9 in 1994, six of which was the effect of home growing. Searching for better varieties than currently cultivated makes the number of rape varieties grow rapidly and at present there are 39 winter rape varieties of bi-zero type in COBORU studies.

From the point of view of agrophysical harvest technology, good grain should not only provide high yields with ensured high oil and ground grain quality, but also be characterized by the following features:

- uniformity of maturation;
- mean resistance to lodging;
- resistance to silique's cracking and seed shedding;
- ability of plant to form corn sealed with branches at silique's layer;
- the optimum number of branches (4-7 per plant);
- location of the first yielding branch at 40-60 cm height above soil surface;
- resistance to fungal diseases;
- tolerance to delayed harvest date.

Today, Polish varieties (Leo, Polo, Bor) decidedly prevail in rape crop structure. For the purposes of technical oil production, older variety Skrzyszowicki is cultivated in northeastern region of Poland due to high content of erucic acid in seeds. Producer's interests can be also focused on spring rape cultivation of new promising varieties Spok, Star and Evita.

## PHYSICAL FEATURES OF CORN

The state of plantation before harvest is a general criterion for application not only of proper harvest technology, but also choosing the right work parameters for the particular cutting and harvesting assemblies. Estimation of the current physical state of corn consists in the evaluation of maturity level, weeding, density, height, and inclination. Not only genetic factors associated with particular varieties, but also agrotechnical operations and soil conditions are important factors influencing the plant's structure. Learning the effect of the above factors on the physical properties of plants can allow for such corn shaping as to make its structure possibly the most proper for the applied harvest technology at the same time ensuring high seed yields.

### THE SOURCES AND REASONS OF THE GROWTH OF RAPE'S SEEDS LOSSES DURING HARVEST

Combine-harvester "Bison" in standard version applied for rape harvest causes great losses. They can be an effect of technical (combine-harvester unprepared to harvest) and technological reasons (work parameters of combine-harvester not adjusted to rape harvest). Seed losses observed for 3411 combine-harvesters produced in standard version (during the first stage of implementation) ranged from 12.2% up to 31% of yield (18.2%, on average).

General assemblies (Fig. 1) having an effect on total seed losses are the following: reaper assembly (1), threshing assembly (2) and cleaning assembly (chaffer) (3).

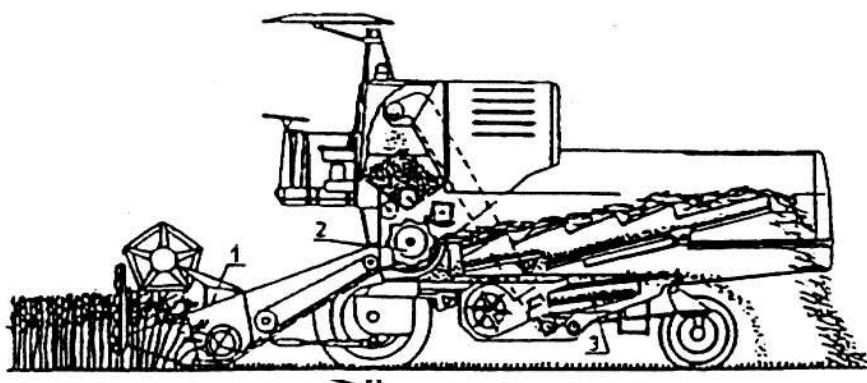


Fig. 1. The sources of the growth of rape seed's losses during harvest with a combine – harvester

Regulations that, for rape harvest, strictly depend on agrotechnical and meteorological factors, corn maturity and harvest method applied, determine the amount of seed losses in these assemblies. Distribution of seed losses due to the work of particular assemblies is presented in Fig. 2.

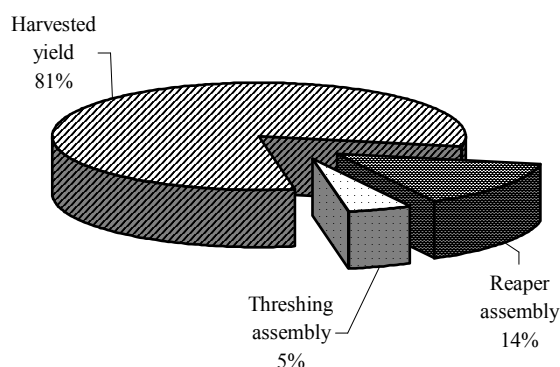


Fig. 2. The rape seed's losses during the harvest with a combine-harvester

## ADAPTATION OF COMBINE-HARVESTER “BISON” FOR RAPE HARVEST

Besides checking the general technical state of the combine-harvester (according to manual), it is particularly important to check in details the seals between the screens and sides of the threshing assembly (state of sackcloth-rubber belts) and covers on seed transporters inside the combine-harvester. Small diameter and spherical shape of rape seeds as well as device vibrations make the seed mass behave as liquid, which affects their easy falling out even through the smallest slots.

Because during rape harvest there is the need to adjust work parameters of combine-harvester to current agrotechnical and meteorological conditions, the technical state of the device for the regulation of the full range of seed sweep, threshing cylinder and ventilator rotations, and for the regulation of the angle of “spike screen” positioning, is important.

The scale of seeds losses in these groups is dependent on specific regulations, which are, for the rape harvest, closely dependable on agrometeorological factors of corn-field maturity and adapted method of the harvest. The table shows the display of seeds loss caused by the work of certain combine-harvester elements.

**Table 1. The rape seed's losses on the commercial field at the harvest with a typical combine harvester (mean from 10 years)**

Reaper assembly's losses		Threshing and Cleaning assembly losses kg/ha	Mean kg/ha	Percentage at yield %
Lateral raw kg/ha	Under straw kg/ha			
199,9	302,7	124,3	357,8	14,1

In order to ensure an optimization of rape harvest process, it is important to adjust the combine-harvester by proper adaptations.

### REAPER ASSEMBLY

Losses caused by a typical reaper assembly range from 50% to 70% of total losses due to the work of a combine-harvester with standard equipment. Among others, too close positioning of cutting mechanism and feeding screw is the reason. Though such construction is plausible at grain harvest (blade ended with a spike whose threshing requires significant power and energy inputs), it cuts rape plants with numerous branches on which delicate siliques are situated, which do not have enough room in the small space between the cutting blade and feeder. Therefore, during cutting, the feeder shifting the upper part of a plant causes the cracking of siliques and falling out the seeds. Seeds that during cutting are shedded just at the cutting blade or directly over it, as well as those knocked out with the energetic work of seed sweep and feeder fingers, are irrevocably lost.

The influence of reaper assembly and harvest time on the quantity of seed's losses (Fig. 3).

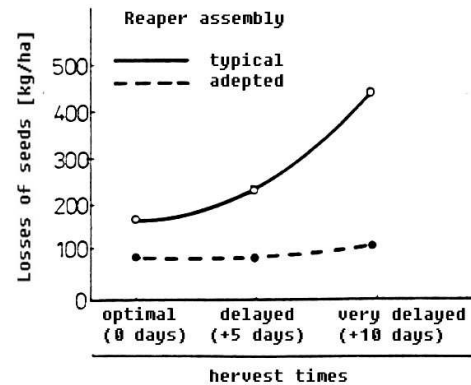


Fig. 3. The influence of reaper assembly and harvest time on the quantity of seed's losses

**Adapter elongating the floor of reaper assembly.** In order to reduce seed losses and adjust standard reaper assembly for rape harvest, adapter elongating its floor by 40 cm was constructed. Adapter can be mounted on every 4.2-meter-width reaper assembly of combine-harvester "Bison".

Application of the adapter significantly reduces the seed losses also at two-stage harvest during cut threshing (without pick-up) by stubble cutting system.

Tests made in many replications at one and two-step rape harvest proved the superiority of the adapted reaper over the standard assembly, and great reduction of losses during harvest using adapted header points out to the usefulness of the application of such solution.

**Cutting assembly.** Rape plant cutting during harvest should be made under the first lower branch. At corn standing or slightly inclined, stubble height amounts to 25-40 cm. Then loading of assemblies threshing and separating the excessive mass of thick stalk parts is decreased. However, the more the plants are inclined, the more the cutting height should be lowered while simultaneously decreasing of the rotational speed of combine-harvester. The optimum working speed for a combine-harvester is the same as for winter grains (2.0-2.5 km/h). It is recommended to work with a combine-harvester at the first running with "variable-speed transmission unit" set in 0-50% range.

**Seed sweep.** During rape harvest, seed sweep can be a very serious source of seed losses. Therefore, special attention should be paid to its regulation and proper work. Peripheral speed of seed sweep should be strictly synchronized with the working speed of combine-harvester (18-22 rpm). A slight increase of seed sweep's peripheral speed is permissible, but not higher than 10% in relation to combine-harvester's working speed. It is applicable at lodged or inclined corn, when plants should be put over reaper assembly before cutting. Seed sweep's fingers should deep into the corn not less than 30 cm and should be set vertically down. Seed sweep should be maximally moved back to reduce seed falling through the floor of the reaper assembly. If the reaper assembly is equipped in adapter elongating the floor, seed sweep should be placed in such a manner that

their fingers inclining the plants were over that floor. At standing or slightly inclined corn, any seed sweep can be omitted.

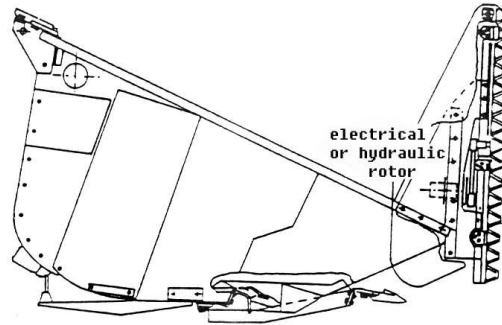


Fig. 4. Active (without fingers) corn divider

**Corn divider.** Studies revealed that the work of a corn divider greatly affects the seed losses during harvest. Passive divider being a part of standard equipment of combine-harvester is commonly applied for rape harvest. The action of a typical passive divider is disadvantageous, particularly at inclined, weeded or very dense corn. Equipping the combine-harvester with this type of divider makes it impossible to cut “in circle mode”, which significantly diminishes combine-harvester’s work efficiency and causes great seed losses. An application of active divider (Fig. 4) totally eliminated the failing observed when using the passive divider.

### THRESHING ASSEMBLY

Parameters of threshing assembly (rotational speed of a cylinder and size of threshing slot at outlet) depend on mass flowing capacity (flow capacity) and on corn or rape cut humidity.

**Threshing cylinder and floor.** Influence of threshing cylinder for two silique’s humidities on the level of seed losses during harvest is presented in Fig. 5.

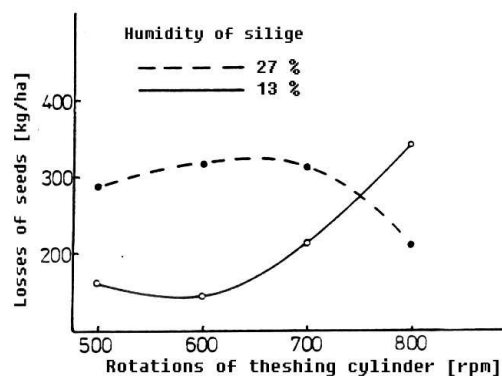


Fig. 5. The influence of cylinder’s rotation and silique’s humidities on the quality of seed’s losses

It was revealed that:

- rotational speed of the threshing cylinder during rape harvest should range between 600 and 800 rpm;
- it is recommended to apply 700-800 rpm for threshing cylinder during harvest of early or wet corn;
- 600 rpm is recommended during optimum and delayed harvest;
- at dry corn harvested at noon hours and cut harvest, it is recommended to apply 550-600 rpm for threshing cylinder.

### CLEANING ASSEMBLY

Adaptation of chaffer's cleaning assembly of the combine-harvester "Bison" for rape harvest (Fig. 6) consists in:

- replacement of standard spike screen with 6-mm-diameter one;
- replacement of lower shutter screen with 4-mm-diameter of round holes.

Moreover, rotational speed of ventilator (1), setting of air-stream nozzles (2), size of slots in upper shutter screen (3) and angle of spike screen placement can be regulated in the chaffer.

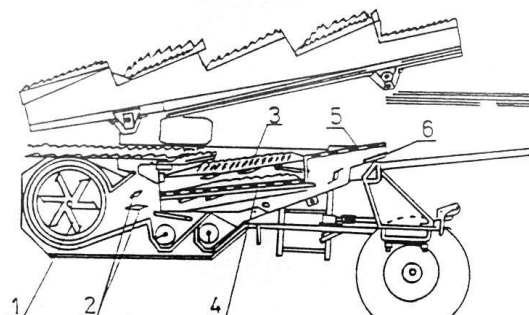


Fig. 6. Chaffer of combine-harvester: 1 – ventilator, 2 – air-stream nozzles, 3 – upper shutter screen, 4 – lower punched-plate  $\Phi$  4 mm, 5 – punched-plate spike screen  $\Phi$  6 mm.

**Punched-plate spike screen.** Standard spike screen consisting in Gerpl's pocket screen and finger grate (comb) caused the return of part of cracked stems by worm and spike transporter back to the threshing assembly, and then the floor of chaffer. It invoked additional and excessive load of the chaffer's upper shutter screen, due to which part of seeds remaining in upper layer of returned seed fell out of the combine-harvester. This is the main reason for threshing assembly's losses during rape harvest. However, the loss level did not exceed 100-150 kg/ha, and a faulty regulation of the parameters of the reaper and threshing assembly's work additionally intensifies these losses exceeding 550 kg/ha under extreme conditions. Application of a new screen with round 5-7-mm-diameter holes, besides the spike one, significantly loads the combine-harvester's chaffer with returned seed and reduces the return of cracked stems through spike transporter back to the

threshing assembly, and thus discharges the threshing assembly and chaffer. Spike screen is mounted in a center hole of a hanger (Fig. 7).

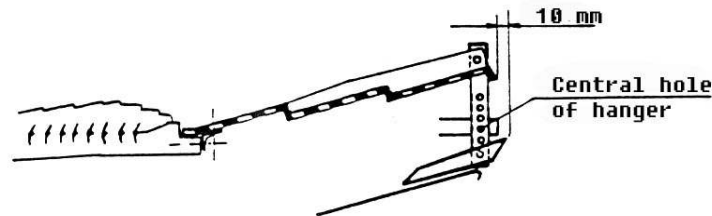


Fig. 7. The setting of punched-plate spike screen

**Inclination angle of spike screen.** Setting the spike screen inclination angle serves for the regulation of mass flow speed through combine-harvester's chaff. When threshing the corn with the lowest humidity at harvest from cuts, screen should be moved up (by one or two holes on hanger), and at wetter corn, the screen should be lowered. The angle of spike screen setting should be practically chosen for every variety and humidity of the harvested corn.

**Lower punched-plate screen.** Besides the spike screen, lower shutter screen should be exchanged into that with 4-mm-diameter round holes. It improves the separation process and contributes to the increase of the seed purity (above 94%).

**Upper shutter screen.** The level of shutter opening depends on the harvested seed humidity: at the humidity above 15%, about 8-mm slots should be applied; at lower humidity and harvest from cuts, the slot should be decreased to 6 mm, which will cause the increase of the harvested seed purity. Measurement of the opening level (slot size) of the upper shutter screen can be done using gap gauge (measurement wedge) in shutter's cuts (in incisions).

**Ventilator.** Rape seed weight varies in a wide range depending on humidity and variety. At ventilator's rotations above 600 rpm, seeds can be blown away onto the field (Fig. 8). Therefore, this range should not be exceeded for seeds with 16-18% humidity. At two-step rape harvest, it is recommended to apply lower range of ventilator's rotational speed. Setting this speed according to the scale (e.g. 1, 2, 3) is burdened with great error (up to 50 rpm). Thus, regulation of the speed using revolution counter is needed.

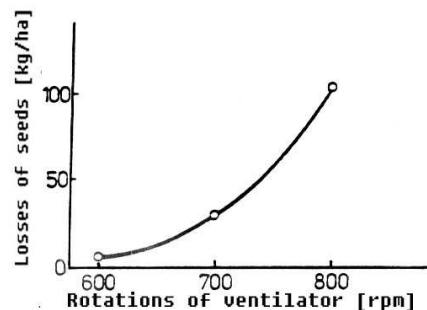


Fig. 8. The influence of the ventilator's rotational speed on the quantity of seed's losses



**Air stream guides.** Upper air stream guides (narrower) should be lowered by 4-6 mm (from the maximum upper position), and the lower one (wider) – in the center of the scale. The proper positioning of air stream guides is illustrated in Fig. 9.

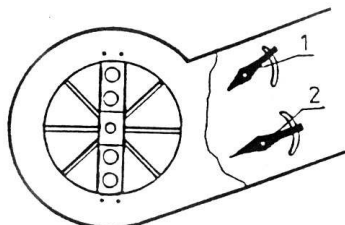


Fig. 9. The setting of air-stream nozzles during rape seed's harvest: 1 – upper nozzle, 2 – lower nozzle

The discussed adaptation of a combine-harvester and recommended regulations of its assemblies are necessary for a proper preparation of the device to one and two-stage rape harvest.

## CONCLUSIONS

The developed technology of rape harvest is based on many-year general and field study results using all the available technical means ensuring a full problem's formulation. Due to an adjustment of all the elements and despite the variation of many factors, the reduction of seed losses was obtained, amounting to 2-3 q/ha as compared to the commonly performed harvest without adaptation and proper regulations of a standard combine-harvester. The 94-98% purity of seeds is an additional effect of the new solutions.

No doubt that not always there is a possibility to adjust all the technical and technological regimes under the production conditions. Nevertheless, even partial application of new technology elements (chaffer adaptation and regulations) brings positive effects. As a result of many-year studies, the data upon seed losses during harvest using standard grain combine-harvesters and after their adaptation to rape harvest, were scrupulously documented. The achieved effect (Fig. 10) depend on such factors as: the amount of biological yield, variety traits, the corn's physical state, environmental and weather conditions, combine-harvester's technical state and operator's skills. Although an experienced farmer can copy with many problems himself, some of them can result from the introduction of a new bi-zero rape varieties not known yet to the producers in view of the susceptibility towards silique's cracking and seed shedding, and first of all, due to great variability of the trait under the influence of maturity and humidity level. Therefore, during bi-zero variety harvest, special attention should be paid to seed sweep's work or to an application of an adapter with elongated floor and active no-finger corn divider. Such combine-harvester's adaptation is at present the only chance to avoid excessive seed losses when harvesting the high-quality varieties that will cover most of the area subjected to rape cultivation in Poland (Fig. 10).

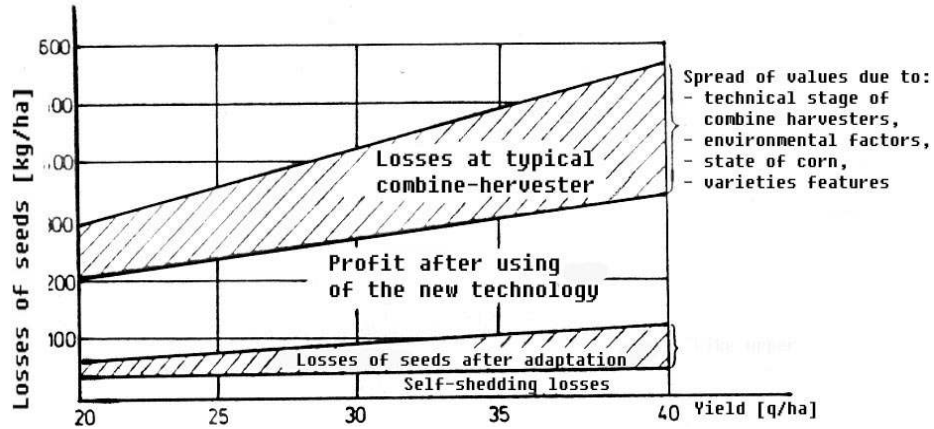


Fig. 10. The relationships between losses of seeds and winter rape's yield at harvest with a combine-harvester based on the practical endorsement of the obtained results.

The numerical data included in Table 2 summarise the essential parts of this paper.

Table 2. Parameters of the work of individual assemblies of Bizon and Bizon-Record combine-harvesters during the rape harvesting

Detailed list	Unit of measure	Values of parameters at harvest	
		One-step	Two-step
Cutting height	cm	25-40	20-35
Rotational speed of sweep	rpm	18-22	-
Rotational speed of chaffer	rpm	-	75-80
Rotational speed of threshing cylinder	rpm	-	550-600
Dry corn	rpm	600	-
Wet corn	rpm	800	-
Size of threshing slot at outlet	mm	-	16
Dry corn	mm	16	-
Wet corn	mm	13	-
Degree of the opening of shutter screen	mm	6	-
Dry corn	mm	6	-
Wet corn	mm	8	-
Kind of lower chaffer's screen	mm	Punched-plate $\Phi$ 4 mm	
Position of punched-plate spike screen	rpm	Central	-
Rotational speed of ventilator	rpm	-	500
Dry corn	rpm	500	-
Wet corn	rpm	600	-
Setting of air-stream nozzles - upper - lower		Under of upper opening Central location	
Day efficiency of combine-harvester $W_{OS}$ for average conditions	ha	5,0	6,0
Purity of seeds	%	94-98	96
Working speed of a combine-harvester	km/hour	2,0-2,5	2,0-2,2

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