

OPTIMUM TECHNOLOGICAL PARAMETERS OF TWO-STAGE HARVESTING OF RAPE*

W. Żak

Institute of Agriculture Mechanization, University of Agriculture, Głęboka 28, 20-612 Lublin, Poland

A b s t r a c t. On the basis of multi-year field and laboratory studies the author determined the optimum parameters of rape harvest according to the two-stage method. The studies were conducted on the Ceres variety, using a Fortschritt E 303 swath mower with an E 327 adapter for rape harvesting, as well as by means of a Z 056 grain combine specially adapted for the pickup and threshing of rape swaths. Analysis was performed for the main factors determining the level of qualitative and quantitative losses occurring in the course of rape harvest.

Observation of the recommendations presented in the paper guarantees a reduction of the quantitative losses of rape seeds and helps obtain better quality of material for the fat industry.

K e y w o r d s: rape, seeds, two-stage harvest, losses

INTRODUCTION

1994 was the year when the four-year depression in rape production was halted. An increase in the profitability of the production of that crop with relation to wheat (in the fall of 1994 the price ratio of the two crops was 2.5 to 1) resulted in an increase in the rape cultivation area from 370,000 ha last year to 490,000 ha this year.

Increase in rape production should also happen through intensification of production, i.e., reducing the losses of seeds with a simultaneous improvement in their technological quality. This is very important, as the atavistic feature of rape plants of their tendency to seed shedding in the case of improper agrotechnical

measures (and especially harvesting) may cause the occurrence of considerable losses, exceeding 25 % of the crop [1,3]. Proper harvesting of rape is the more important since the new varieties introduced in recent years (improved in yield and content of erucic acid) are, unfortunately, characterized by an increased susceptibility of siliques to cracking.

As was demonstrated by the study, the strength properties of the double-low varieties are twice and even three times poorer than those of varieties cultivated earlier (e.g., the Górczański variety) [2].

Apart from the varietal features, the level of seed losses during the two-stage harvest is also determined by such factors as:

- the meteorological conditions prevailing during the harvest,
- the degree of plantation infestation with pests and weeds,
- the moisture content of the seeds,
- the uniformity of ripening of the canopy,
- the choice and adaptation of harvesting machinery and observation of suitable working parameters of the machines used,
- the harvest technology and timing.

In agricultural practice, two methods of rape harvest are currently in use:

- one-stage, realized through direct threshing

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of the canopy at full ripeness of seeds (acc. to assessments this method is used on approximately 60 % of the rape growing area),

- two-stage, when rape at technical ripeness is cut using a swath mower, then threshed by means of a grain combine after drying.

The application of the two-stage method permits earlier beginning of rape harvest and facilitates uniform ripening of seeds, which provides a possibility of obtaining material of a lower moisture content. If, however, heavy rainfall occurs during the drying of the swaths, the quantitative losses of seed increase, the harvest period extends, and the harvest itself becomes more difficult. Another disadvantage of the method is the necessity of using two machines, which increases the energy requirements of the method, and therefore its economical effects deteriorate.

The opinions of both farmers and research workers on the advantages and disadvantages of the methods under discussion are frequently divergent, depending on the criterion they adopt and also on regional customs [2,4].

Undoubtedly, the two-stage, thought by some rape producers (in the Poznań, Gorzów, and Opole districts) to be the best, requires considerably higher skills, experience, as well as closer observation of technological regimes than is the case with the one-stage method.

The objective of this study was to determine the optimum technological parameters of two-stage rape harvest, the application of which would ensure the minimum of quantitative and qualitative losses.

METHODS

The study on the two-stage method of rape harvest was based on the Ceres variety and it was conducted during the period of 1987-1994 at the Tarnogród State Farm (Zamość District), at the Plant Breeding Station and the Variety Evaluation Station in Ządąbrowie (Przemyśl District), at the Obsza State Farm (Zamość District), and some of the observations and measurements were performed in the Toruń District.

For the cutting of rape and laying it down

in swaths, a German swath mower was used, type Fortschritt E 303, together with the E 327 swath-laying unit, specially designed for the purpose. The pickup and threshing of dried swaths (when seed moisture content was 8-10 %) was performed using a modified Bizon Z 056 combine. The scope of the modification is described by Szot *et al.* [5].

To compare the quality of work and to determine the differences in seed losses in the variants of the two-stage harvest technology used, the swath pickup was made using a combine equipped with three different headers:

- standard version (series produced for the Bizon combine),
- adapted, equipped with an adapter extending the floor by approximately 40 cm,
- standard, equipped with a reel-and-finger feeder, manufactured by the Harvesting Machinery Co. in Plock.

In the first two cases, the pickup was effected according to the 'double-cutting' method, i.e., through repeat feeding by the cutting bar of the lower parts of rape stems (stubble). Using the swath pick-up, seed loss assessment was performed at three feeder drum speeds - maximum, minimum, and an intermediate speed which was the arithmetic mean of the extreme speed settings. The determination of the level of seed losses was performed according to the method described by Tys [7]. The weight ratio of seeds lost to the sum of seeds lost and seeds collected in the grain tank was the seed loss value. The losses were most often expressed in percentages.

To determine losses resulting from rape seed shedding during the drying of swaths, a special method was developed for the determination of the level of such losses. A cut and formed swath (of a length of 1.25 m) was placed on wiremesh with 10 x 10 cm grid, at a height of about 15 cm above the ground, preserving its continuity and structure. On the ground beneath the mesh another wiremesh was placed, this one with 1 x 1 mm grid. Such an arrangement of screens ensured the preservation of the same moisture conditions as in the whole of the swath. As a result, seeds

shedding from the swath passed the large-grid mesh and fell onto the screen placed directly on the ground. The seeds were collected from the lower screen once a day and their weight was determined, this operation being repeated from the moment of cutting by the swath mower until the moment of swath threshing by the combine.

All the weight results are given after their conversion from the actual moisture content to weights corresponding to seed moisture content of 12 % (acc. to the standard PN-78R-65023).

Seed damage occurring in the two-stage harvest technology was assessed according to the method described in paper [6]. In the course of the study, an abbreviated evaluation of the mower was performed, according to applicable requirements of the standard No. PN/R-55020.

RESULTS

The technical evaluation carried out in the period of 1988-1990, as well as the determination of the working parameters of the Fortschritt mower substantiate the statement that the machine works well and is characterized by good technical and technological parameters (Tables 1 and 2).

Only in the first year of operation did a low index of technical reliability result from manufacturing defects which disturbed the operation of the mower. It should also be pointed out that the E 327 adapter has a number of design deficiencies, which affects the quality of its operation and thus also the resultant level of seed losses. When rape is cut and fed into the machine, the plants get caught (mainly by their upper parts) on the header cowlings. This is especially noticeable when swathing non-homogeneous plants, characterized by numerous branchings, with the first branching placed low on the plant. In extreme cases (most evident in 1990), this could lead to a temporary interruption of the outflow of the mass being cut, causing local thickening of the swath. The passage of the machine over a swath already formed (especially with a well

Table 1. Selected working parameters of the mower

Specification	Unit	Year	
		1988	1989
True working width	m	3.96	3.92
Swath spacing	m	1.98	1.96
Swath height	m	1.04	0.83
Swath width	m	1.94	2.03
Weight of 1 m of swath	kg	5.60	5.34
Stubble height	m	0.31	0.32

Table 2. Selected operational parameters of the mower

Specification	Unit	Year		
		1988	1989	1990
Efficiency per working shift (W_{08})	ha/h	1.6	1.3	1.4
Effective efficiency (W_1)	ha/h	2.1	1.7	1.9
Index of technological reliability	-	0.95	0.90	0.90
Index of technical reliability	-	0.78	0.92	0.88

developed canopy) also causes an additional increase in the level of seed losses. Observations conducted in production fields indicate that harvesting machine operators often use excessive working speeds, which, in the case of a plantation infested with pests or plant disease, or in the case of swathing after the optimum time, leads unavoidably to increased seed losses. Perhaps in the new model of Fortschritt mower (type 4304), currently being introduced into the Polish market, at least some of these deficiencies have been eliminated. It is certain that the application of a new gearbox with a foot-operated clutch (replacing the poorly working hand-operated former design), as well as the system of switching the direction of rotation, will make the work of the operator easier and let him devote more of his attention to the quality of the job he is performing with his machine. Also the application of electronic instrumentation and warnings and improvements in the comfort level of the cabin (adjustable windshield tint, among other things) should have an indirect but beneficial

effect on the level of quantitative losses of rape seeds. Unfortunately, the potential application of the new model is severely limited by its very high price in Poland (currently the equivalent of over 61 thousand USD). In 1989 tests were conducted on the application of a mower for the cutting of a rape canopy with a very high degree of weed infestation, at delayed harvest time. These tests showed that overly delayed cutting to swaths causes very high seed losses. Also attempts at solving this problem by swath cutting very early in the morning ('dew-time harvest') did not bring any improvement. This shows that the suggestions that canopies with high weed infestation should be harvested in two stages ought to be complemented with the conditions of absolute observation of a sufficiently early harvest time. It was concluded that the optimum time for rape cutting to swaths is the moment the plants reach technical ripeness. This moment can be determined by bending siliques to the

uniform ripening of plants) and requires considerable experience.

The effect of the time of cutting to swaths on the level of seed losses has been discussed by Tys [7].

In every year of the study the losses of seeds in the swath through shedding were determined. It was observed that daily losses through seed shedding in the swath varied widely, from 0.5 to 5.0 kg/ha. Most frequently, however, such losses were within the range of 2-3 kg/ha, and their total value over the period of swath drying can be stated as about 30 kg/ha. It was observed that rainfall as well as winds of velocities over 15 m/s may cause a significant increase in the level of such losses, even doubling their level. An example of this situation is presented in Fig. 1.

Another element affecting the level of seed losses is the type of equipment used for swath threshing and the parameters of its operation (Tables 3 and 4).

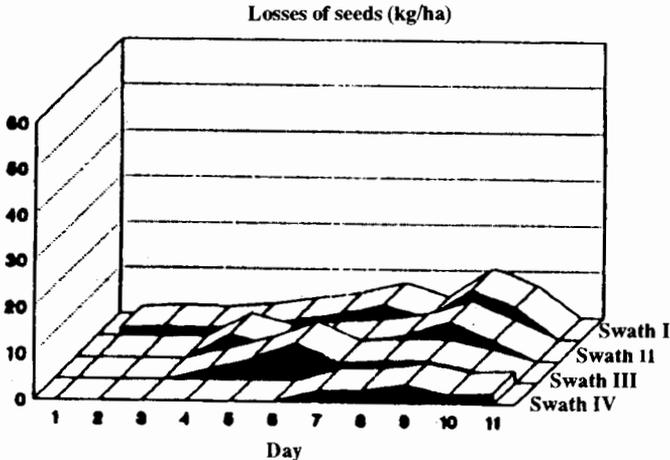


Fig. 1. Seed losses caused by shedding in swaths in 1992.

shape of the letter U. Siliques bent to this shape should open at the folding points, revealing green seeds with brown and black spots. At the same time the canopy gets discoloured from deep-green to pale-green. It is assumed that in that period a plantation should have about 60 to 70 % of siliques at this stage of ripeness. Years of practice proved that the determination of this stage of ripeness for the whole canopy is very difficult (due to the non-

The results presented here permit the statement that the most favourable method of swath pickup is the application of the feeder and the header with extended floor. The application of the standard harvester configuration is a solution causing the highest losses of all the variants of harvest technology under discussion. Losses occurring in the course of operation of the feeder are determined by the speed of the feeder drum. It should be adjusted

Table 3. Average rape seed losses in the application of various headers and swath pick-up units in two-stage harvest.

Year	Seed losses	Header		Swath pick-up
		Standard	Adapted	
1988	average, kg/ha	148.7	136.2	97.5
	% of crop yield	6.3	5.4	3.9
1989	average, kg/ha	258.6	154.9	223.7
	% of crop yield	8.6	5.0	7.3
1990*	average, kg/ha	794.7	777.9	734.1
	% of crop yield	33.1	29.0	25.8

*For research purposes, in 1990 swath pickup was performed at a delayed time, which was apparent in the level of seed losses.

Table 4. Rape seed losses in harvest with swath pick-up, for three speeds of feeder drum. Delayed cutting to swaths

Seed losses (kg/ha)	Feeder drum speed		
	7.8 rad/s	9.4 rad/s	10.5 rad/s
Average	734.1	847.6	1020.5
% of crop yield	25.8	35.0	37.5

so that the rotational speed of the tips of the fingers is about 10-20 % higher than the forward speed of the combine.

Studies have shown so far that the lowest losses occur at the minimum speed, i.e., about 7.8 rad/s. Any increase in the speed causes an increase in the level of seed losses; at a speed of about 10.5 rad/s (i.e., the maximum speed) seed losses may even increase by about 50 %.

A significant cause of lowered quality of rape seeds is their mechanical damage through the effect of the working elements of machinery used for the harvest. To determine the level of the damage and the location of the source of its occurrence, a field experiment was carried out in the period of 1992-1993, in which a combine equipped with a finger-and-drum swath pick-up was used. Seed moisture content at the moment of swath threshing was 8.0-8.9 %, and the combine operation parameters used were as follows:

- threshing drum speed - 600 r.p.m. (63 rad/s),
- fan speed - 600 r.p.m. (63 rad/s),
- threshing drum working slot - 16 mm,

- pick-up drum speed - 7.8 rad/s.

A significant differentiating factor was the time of cutting to swaths: early (I), optimum (II), delayed (III), and very delayed (IV). The results obtained are presented in the form of a graph in Fig. 2.

CONCLUSIONS

1. The Fortschritt E 303 swath mower with the E 327 adapter is a machine characterized by good technical parameters and high efficiency.

2. The daily seed losses through shedding in the swath were relatively stable at 2-3 kg/ha, which gave a total for the whole period of swath drying at about 1 % of the crop yield. Rainfall in the area, and especially strong wind (over 15 m/s) caused a considerable increase in the level of the losses.

3. A delay in the time of rape cutting to swaths by 3-5 days with relation to the technical ripeness of the plants causes a strong (even double) increase in the level of losses caused by the mower and the combine. It also has a significant and unfavourable effect on the number of damaged seeds.

4. The lowest losses in the cutting and threshing of swaths occur with the application of the modified harvester with extended header floor or the finger-and-drum swath pick-up. It is recommended to use the minimum feeder drum speed of 7.8 rad/s.

5. Combine pickup of swaths should be made using the following parameters:

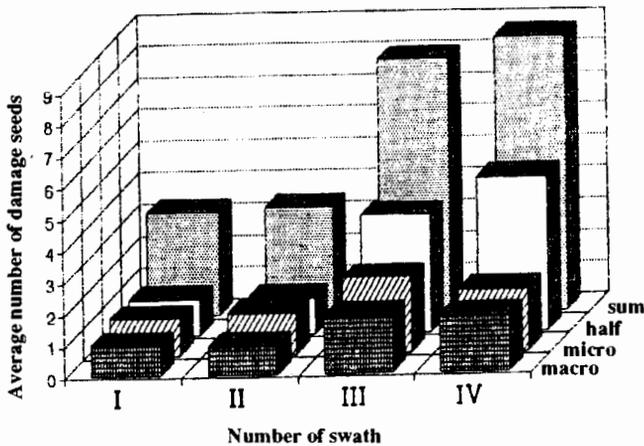


Fig. 2. Average number of rape seeds damaged in two-stage harvest at various times of cutting to swaths.

- threshing drum speed - 600 r.p.m.,
- fan speed - 600 r.p.m.,
- maximum setting of threshing drum slot - 16 mm.

6. Limitation of quantitative and qualitative losses of seeds in two-stage harvest requires absolutely strict observation of technological regimes as well as considerable experience.

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OPTYMALNE PARAMETRY TECHNOLOGICZNE DWUETAPOWEGO ZBIORU RZEPAKU

Na podstawie wieloletnich badań polowych i laboratoryjnych określono optymalne parametry zbioru rzepaku metodą dwuetapową. Badania prowadzone były na odmianie Ceres, z zastosowaniem kosiarki pokosującej Fortschritt E 303 wyposażonej w specjalny adapter do zbioru rzepaku E 327, a także adaptowany - specjalnie do potrzeb zbioru i omłotu pokosów rzepaku - kombajn zbożowy Z 056. Analizie poddano główne czynniki decydujące o wielkości strat ilościowych i jakościowych występujących podczas zbioru.

Zastosowanie się do przedstawionych zaleceń gwarantuje ograniczenie strat ilościowych nasion a także przyczynia się do uzyskania lepszego surowca technologicznego dla przemysłu tłuszczowego.

Słowa kluczowe: rzepak, nasiona, zbiór dwuetapowy, straty.