The estimation methods of oilseed rape harvesting losses

R. Domeika, A. Jasinskas, D. Steponavičius, E. Vaiciukevičius and V. Butkus

Department of Agricultural Machinery, Lithuanian University of Agriculture, Studentų 11, LT-53361 Kaunas, Lithuania; e-mail: Rolandas.Domeika@lzuu.lt

Abstract. Oilseed rape harvesting losses, which occur during cutting, separation and cleaning and shaking, reach 5–10%; cutting and separation processes account for 80–90% of the total harvesting losses. A special test stand was prepared for the research of oilseed rape cutting and separation losses. It was established that the active twin-blade knife separator and the passive triangular separator on the header of a harvester have influence on the separation losses in 0.5 m on both sides of the separator motion line. Separation losses using the active twin-blade knife separator were twice less than using the passive triangular separator. The optimal active twin-blade knife separator moving speed is 5 km h^{-1}. The analysis of the research results has revealed that traditional estimation methods of oilseed rape harvesting losses are not correct and it is necessary to use a 0.1x0.1 m wire frame for the estimation of cutting losses and a 0.1x0.5 m wire frame for the estimation of separation losses.

Key words: Oilseed rape, harvesting, losses, loss estimation methodology

INTRODUCTION

Cereals in Lithuania occupy approximately 45% of the whole area under cultivation. The number of farmers growing oilseed rape is increasing: in 1995 the area occupied by oilseed rape comprised 14 thousand ha; in 2005 the number increased to approximately 80 thousand ha and the European Union has requested an increase to 250 thousand ha to yield 500 thousand tonnes of seeds harvest (Raicevičienė, 2006). The Common Agricultural Policy of the European Union and increase in land use for oilseed rape in the EU countries (IENICA, 2005) are pushing forward a move to increase oilseed rape production in Lithuania, too. But there are many agro-technical issues to be solved, among them the question of oilseed rape harvesting.

Oilseed rape is harvested directly with a combine harvester, which spills 5–10% of seeds (Lazarichieva, 1988; Price at al., 1996; Špokas et al., 2004). The main reasons for seed losses are as follows: late harvesting time, shortage of the twin-blade knife separators or additional tables with the active separators of headers (Feiffer et al., 1996; Domeika et al., 1999) and the oilseed rape harvesting method (Price et al., 1996; Velička, 2002). The oil seed rape harvesting method depends on pod characteristics (Davies & Bruce, 1997). Although it is possible to use the swath harvesting method for some varieties of summer oilseed rape (Kimber & McGregor, 1995; Price et al., 1996), it has been established and recommended that the best method is direct harvesting (Feiffer et al., 1996; Price et al., 1996; Domeika et al., 1999). The starting time and duration of rape harvesting and the expediency of using the twin-blade knife separator and the additional header table have also been established (Macleod, 1981; Domeika, 1998; Špokas et al., 2004). The moisture of oilseed rape and natural seed fall losses are determined using standard methods (Feiffer et al., 1996; Špokas et al., 2004). Under production conditions direct oilseed rape seed cutting and separation losses are determined by the wire frame (0.1x0.1 m) put on the harvester's track establishing cutting losses or on the separator's 0.1 m run line establishing separation losses (Domeika, 1998). Seeds and pods in the area of each frame are collected, pods are threshed, and all seeds are weighed; cutting and separation losses are calculated in % (Domeika, 1998). To establish and calculate oilseed rape cutting and separation losses the width of 0.1 m from the separator run line is evaluated. Since it is not clear at what width seeds threshed by the separator are dispersed, the determination of losses and evaluation of the 0.1 m width are not exact.

The aim of the investigation was to establish the interaction between the separator of a combine harvester header and oilseed rape plants, evaluating dispersion of oilseed rape seeds threshed by the separator and using results of the experiments to correct the method of estimating cutting and separation losses.

MATERIALS AND METHODS

The active twin blade knife separator or the passive triangular separator was mounted on the right side of the combine harvester header. The interaction between the separator and oil seed rape plants was established in an artificial oilseed rape plot. The special test stand with a length of 5 m and width of 1.5 m consisted of a 5x1.5x0.15 m frame with rape plants holders (Fig. 1). The canvas surface of holders had a roof form that guaranteed even dispersion of rape seeds threshed by the separator. It was possible to change the distance between the rape plant holders from 0.15 to 0.45 m. Rape plants were attached to holders using the chequerwise principle with the space of 0.15 m in every holder. It was possible to change oilseed rape crop density from 60 to 180 units m^{-2}.

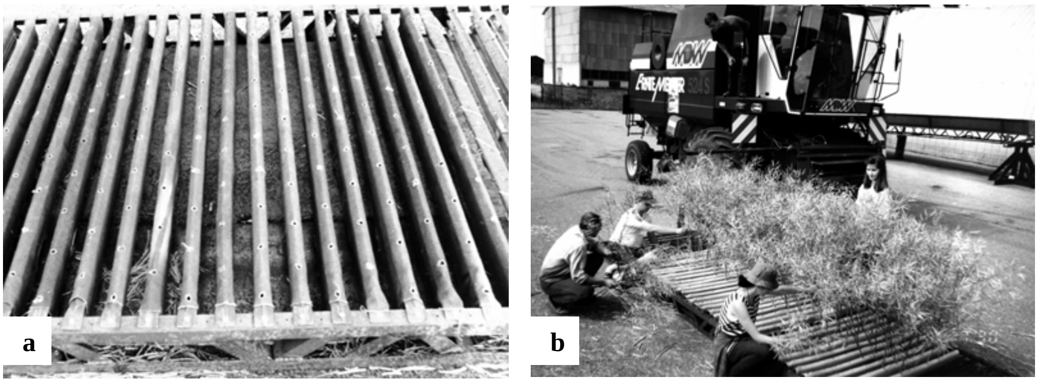

Fig. 1. Artificial oil seed rape plot:
a - rape plant holders, b - making of rape plot.

The canvas trail measuring 5.0x1.5 m was divided into 0.1x0.5 m plots and was inserted under the rape plant holders. The separator was moved along the central line of the plot. Cut, broken pods and threshed seeds were counted and seed losses were calculated.

RESULTS AND DISCUSSION

The dispersion of oilseed separation losses using the active twin-blade knife separator was established in the artificial winter oilseed rape 'Senta' plot (crop density 70 units m^{-2}), when the moisture of seeds was 32 and 18% (Fig. 2). When the separator was moving at 10 km h^{-1}, the threshed seeds and cut pods were dispersed along the 0.5 m wide track on both sides of the separator action line. 15% of all seeds with 18% moisture (Fig. 2, d) and 27% of all seeds with 32% moisture (Fig. 2, c) were spread at the separator moving line. At the speed of 2 km h^{-1} seed dispersal width did not change but seeds were less scattered.

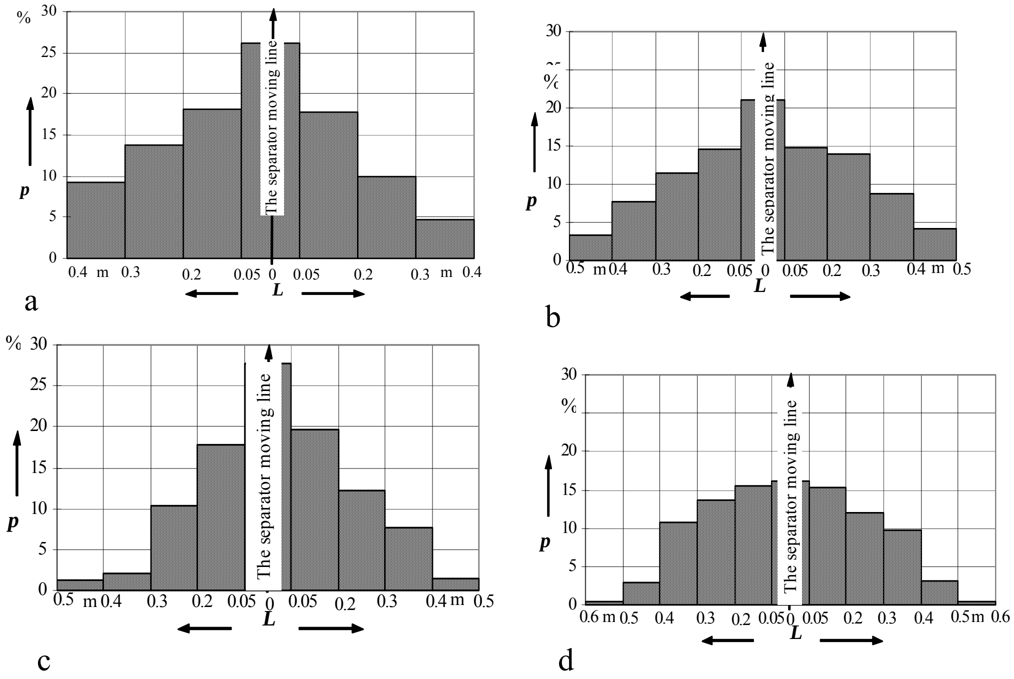

Fig. 2. Dispersion (p) of winter oilseed rape 'Senta' losses in the artificial plot (*L*):

a – moisture of seeds 32%, separator motion speed 2 km h^{-1},
b - moisture of seeds 18%, separator motion speed 2 km h^{-1},
c - moisture of seeds 32%, separator motion speed 10 km h^{-1},
d - moisture of seeds 18%, separator motion speed 10 km h^{-1}

In the plot of summer rape 'Star' (crop density 140 units m^{-2}, moisture of seeds 20%) the seeds were spread along the 0.5 m wide track on both sides of the separator and rape interaction line when the separator motion speed was changed from 2 to 8 km

h^{-1}. Approximately 38% of seeds were spread on 0.1 m track and only about 4% on the edge tracks (Table 1).

Table 1. Dispersion of summer oilseed rape 'Star' losses in the artificial plot (crop density 140 units m^{-2}, moisture of seeds 20%).

Distance from the separator moving line, m	0 ÷ 0.1	0.1 ÷ 0.2	0.2 ÷ 0.3	0.3 ÷ 0.4	0.4 ÷ 0.5
Number of seeds, %	38	30	18	10	4

The analogical results were observed in the artificial winter oilseed rape (crop density 70 units m^{-2}, moisture of seeds 18%), when the passive triangular separator was mounted instead of the active twin-blade knife separator. Cut, broken pods and threshed seeds were spread 0.5 m wide on both sides along the separator moving line after changing the separator moving speed from 2 to 8 km h^{-1}.

The influence of the active twin-blade knife separator motion speed on winter oilseed rape (crop density 70 units m^{-2}, biological harvest 2.6 t ha^{-1}, moisture of seeds 18%) separation losses was established. While changing the separator motion speed from 2 to 10 km h^{-1}, the losses of winter rape seed separation increased from 0.5 to 1.2% (Fig. 3). The losses of summer rape seed separation were much less than those of winter rape. While changing the separator motion speed from 2 to 8 km h^{-1}, the losses of summer rape seed (crop density 140 units m^{-2}, biological harvest 3.0 t ha^{-1}, moisture of seeds 20%) separation increased from 0.1 to 0.2%.

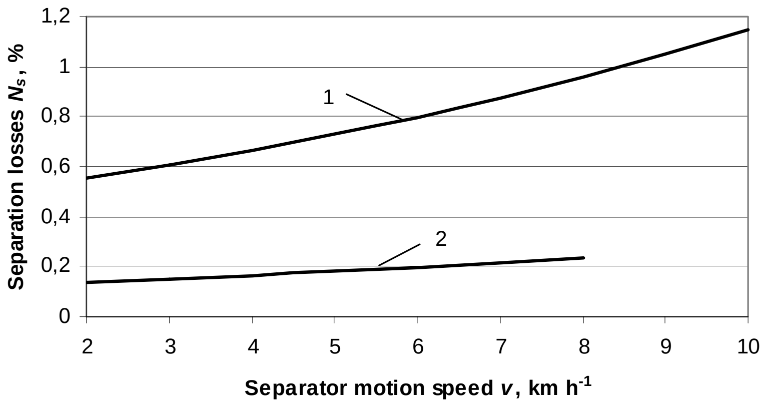

Fig. 3. The influence of the active twin-blade knife separator motion speed v on separation losses in the artificial plot N_s:

1 - winter rape $N_s=0.462e^{0.091v}$, R^2=0.90;
2 - summer rape $N_s=0.117e^{0.0087v}$, R^2=0.92.

Analysis of the structure of the active twin-blade knife separation losses has established that cut branches are mat and they stay dangling on the rape plants. Reel pins push cut branches on the header during harvesting and that does not influence the separation losses. The number of cut and broken pods increased when the separator moving speed did not exceed 4.5 km h^{-1} (Fig. 4).

The number of broken pods increased when the separator moving speed exceeded 5.5 km h^{-1} and in that case the number of cut pods decreased, because knives of the separator did not catch to cut all pods. The minimal number of cut and broken pods was observed when the separator moving speed was about 5 km h^{-1}. Analogical results were obtained in the artificial summer oilseed rape plot.

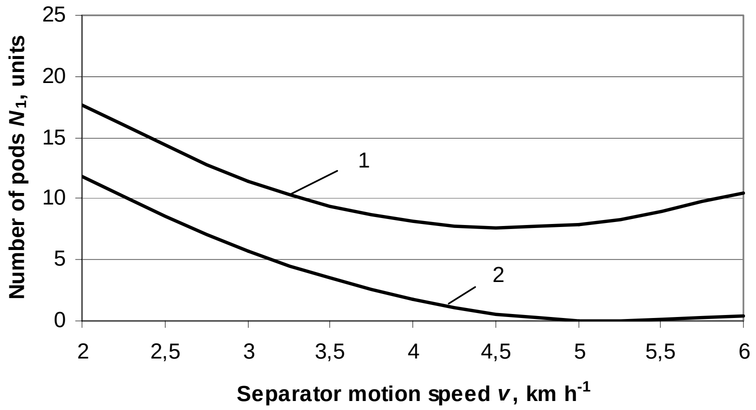

Fig. 4. The influence of the active twin-blade knife separator motion speed v on the number N_1 of cut and broken pods of winter oilseed rape 'Senta'

(crop density 70 units m^{-2}, moisture of seeds 40%):

1- broken pods $N_1=1.5v^2 - 13.8v + 39.32$, $R^2 = 0.88$;

2- cut pods $N_1=1.0v^2 - 11.64v + 30.69$, $R^2 = 0.95$.

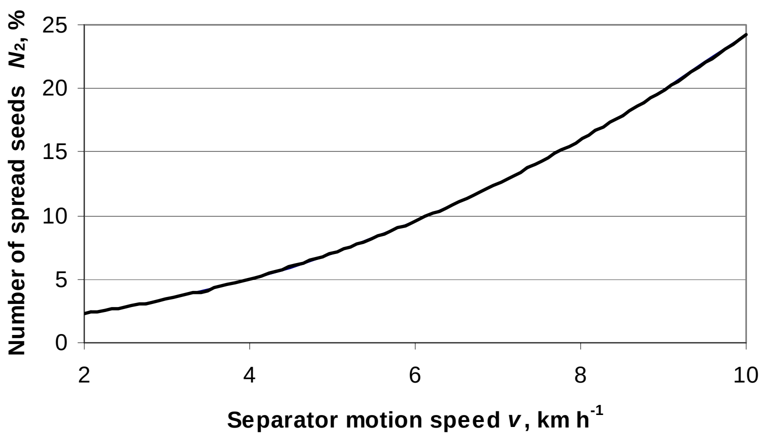

Fig. 5. The influence of the active twin blade knife separator motion speed v on the number N_2 of spread winter oilseed rape 'Senta' seeds:

$N_2=0.231v^2 - 0.0295v + 1.45$, $R^2 = 0.96$.

The number of spread seeds (winter oilseed rape 'Senta', crop density 70 units m^{-2}, moisture of seeds 18%) increased from 2 to 25% (total number of spread seeds 47755 units), when the separator motion speed was changed from 2 to 10 km h^{-1}. The number of spread seeds was less than 7 %, when the separator motion speed was changed from 2 to 5 km h^{-1} (Fig. 5) and the number of spread seeds started increasing when the separator motion speed exceeded 5 km h^{-1}. The same seed spread tendencies were observed in the summer oil seed rape 'Sponsor' artificial plot. It was established that oilseed rape separation losses using the active twin-blade knife separator were twice less in comparison to the passive triangular separator.

Summarizing the research results it should be maintained that the optimal active twin-blade knife separator motion speed is 5 km h^{-1}. Cut and broken pods and seeds disperse in the width of 0.5 m on both sides of the separator moving line; traditional estimation methods of oilseed rape cutting and separation losses under production conditions using 0.1x0.1 m wire frame are not correct. It is expedient to use two types of wire frames: 0.1x0.1 m - for evaluation of cutting losses and 0.1x0.5 m – for evaluation of separation losses.

It is necessary that a combine harvester stays back not less than 15 meters from the beginning of the oilseed rape field when it begins a steady working process. Evaluating cutting losses 0.1x0.1 m wire frame must be put chequerwise 20 times on both sides of the straw swath to 0.5 m wide plot, where there is the separator influence area (Fig. 6).

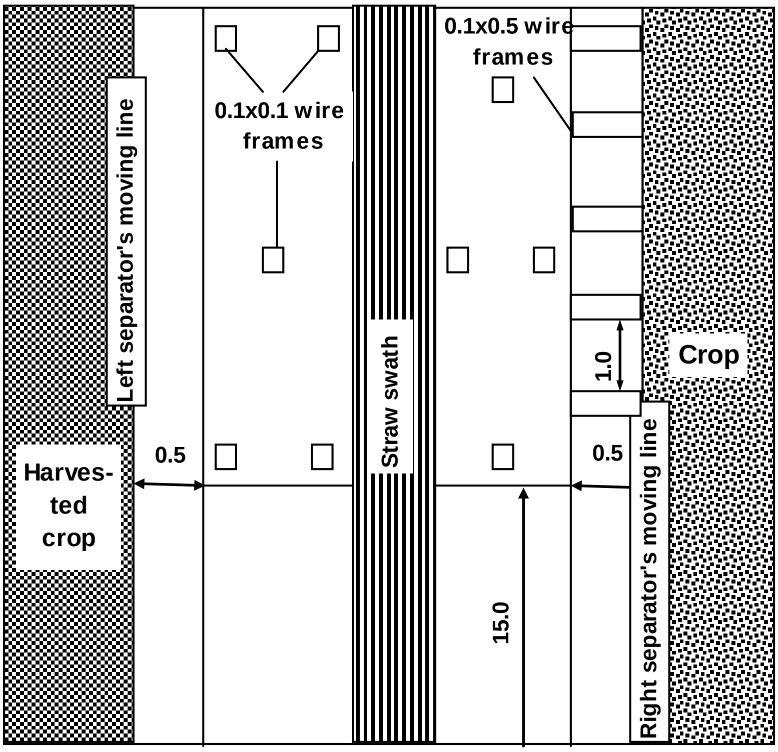

Fig. 6. The scheme for oilseed rape cutting and separation losses estimation method.

Seeds and pods in the area of each frame must be collected, pods must be threshed, and all seeds in every frame and the average of seeds must be calculated. Oilseed cutting losses N_C in % are calculated as follows:

$$N_c = \frac{k a_1 m}{10 h_b}, \quad (1)$$

where a_1 – average seed number in the area of the 0.1x0.1 m frame, units;
m - average mass of one 9% moisture rape seed, g;
h_b - biological oilseed rape harvest, t/ha,
k - coefficient (Table 2).

Table 2. Values of coefficient *k*.

Header width, m	6.0	5.4	5.0	4.8	4.5	3.2
Coefficient *k*	833.3	815	800	791.7	777.8	687.5

In evaluating separation losses, a 0.1x0.5 m wire frame must be put 20 times at the distance not less than 1 meter between each frame in the 0.5 m wide plot from the right separator moving line in the separator influence area (Fig. 6). Seeds and pods in the area of each frame must be collected, pods must be threshed, and all seeds in every frame and the average of seeds must be calculated. Oilseed separation losses N_S in % are calculated as follows:

$$N_S = \frac{(1000 - k) a_2 m}{50 h_b} - N_C, \quad (2)$$

where a_2 – average seed number in the area of the 0.1x0.5 m frame, units;
m - average mass of one 9% moisture rape seed, g;
h_b - biological oilseed rape harvest, t ha^{-1};
k - coefficient (Table 2);
N_C – cutting losses, %.

CONCLUSIONS

1. Minimal oilseed rape separation losses are observed when the active twin-blade knife separator motion speed is 5.0 km h^{-1}.

2. Rape seeds threshed by the active twin blade knife separator, cut and broken pods disperse along the 0.5 m wide track on both sides of the separator action line.

3. Traditional estimation methods of oilseed rape cutting and separation losses under production conditions are not correct, therefore, to obtain the correct values of losses, the following points should be observed:

3.1. For estimation of oilseed rape cutting losses it is necessary to use 0.1x0.1 wire frame which must be put on both sides of the straw swath till 0.5 m wide plot where there is a separator influence area and equation for calculation should be used (1).

3.2. For estimation of oilseed rape separation losses it is necessary to use 0.1x0.5 m wire frame which must be put in the 0.5 m wide plot from the right separator moving line in the separator influence area and (2) equation for calculation should be used.

REFERENCES

Davies, G.C. & Bruce, D.M. 1997. Fracture mechanics of oil seed rape pods. *Journal of Materials Science* **32**(22), 5898–5899.

Domeika, R. 1998. *Studies of interaction between twin-blade knife separator, reel and ail seed rape plants and seed losses*: *The thesis of doctor.* Akademija, Kaunas, 98 pp. (in Lithuanian).

Domeika, R., Špokas, L. & Butkus, V. 1999. Research of Rapeseed Harvesting Losses. *Proceedings of the Latvia University of Agriculture* **1**, 28–35.

Feiffer, A., Feiffer, P. & Göbel, D. 1996. Rapsernte. *Raps* **3**, 136–139.

IENICA. 2005. *European summary report 2000–2005.* Web site: www.ienica.net/ienicareports.

Kimber, D.S. & McGregor, D.J. 1995. *Brasica Oilseeds: production and utilization*. CAB International, Wallingford, 400 pp.

Lazarichieva, S.G. 1988. *Technology of harvesting, storage and use oil seed rape.* Novosibirsk, 40 pp. (in Russian).

Macleod, J. 1981. *Oilseed Rape Book.* Cambridge Agricultural Publishing, Cambridge pp. 107–119.

Price, J.S., Hobson, R.N., Neale, M.A. & Bruce, D.M. 1996. Seed losses on commercial harvesting of oil seed rape. *Journal of Agricultural Engineering Research* **65**, 183–191.

Raicevičienė, A. 2006. Plants for not food use. *The Scientific Conference "Plants for not food use, production of bio-diesel and bio-ethanol"*. Lithuanian Advisory Service, Dotnuva, pp. 1–4 (in Lithuanian).

Špokas, L., Velička, R., Marcinkevičienė, A. & Domeika, R. 2004. Optimierung des Erntezeitpunktes von Sommerraps durch die Sortenwhahl. *Die Bodenkultur.* **55**(3), 113–120 (in German).

Velička, R. 2002. *Oil seed rape: Monograph.* Akademija, Kaunas, 320 pp. (in Lithuanian).