Brassica Carinata Harvesting Losses Reduction

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ABSTRACT

The Brassica Carinata cultivation has recently gained, also in Italy, an increasing interest due to the reduced seed losses in respect to the Brassica Napus. As the Brassica Carinata plantation presents a good natural resistance to the dehiscence process, it allows for considering unnecessary the use of specified heads that are the same employed for the rapeseed harvesting, giving a losses reduction but an increase in costs. From the tests conducted in the plain of Ravenna in 2008, the reduced seed losses were only reported in the areas where the Brassica Carinata plants were not so high, not particularly tangled and without allotment. In this case, in fact, the rubbing action of the head separator can cause losses due to the opening of the detached siliquae. Furthermore the working capacity of the combine harvester can suffer negative consequences from the entanglement of the plants. Thus, it is necessary to careful evaluate the characteristics of the plantation as the growth and the entangled level before choosing the most suitable unit to harvest. The same harvesting machine on different plants can cause an improvement of harvesting costs as well as less profits due to a more seed losses.

Keywords: Brassica carinata, wheat combine harvester, biofuels, Italy.

1. INTRODUCTION

Brassica Carinata is a native plant of eastern Africa that is an herbaceous, annual plant and, among the energy crops for biodiesel production, it has recently gained special attention also in Italy.
Like other Brassicaceae, Brassica Carinata can grow on both sandy and clayey soils as long as they are well drained. Besides this, it shows a good degree of resistance to some of the plant diseases that often have affected the production of traditional oil-seed rape (Brassica Napus var oleifera).
The main characteristics of a Brassica Carinata plantation are summarised in the following list:

- It does not present particular problems, especially because of its high adaptability to different pedoclimatic conditions in the centre and south of Italy;
- It shows a good resistance to the dehiscence of mature siliquae that reduces the pre-

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harvest losses that have often prevented Brassica cultivation on a large scale;
- It is characterized by both a high oil content (from 32% to 49%) and a concentration of fat in the oilcake of over 8% (sometimes 10-15%).

The mechanized harvesting of Brassica represents an important aspect for the economic consequences on costs and yields. To this end, it is important to verify the efficiency of the available harvesting systems, most of which are characterized by a commercial wheat combine harvester either provided with specified devices or not.
To this end, CRA-ING, after the experimental proof on rape (Brassica Napus) harvesting done in 2007 (L'informatore Agrario n. 22/2008 page 39), carried out an evaluation of Brassica Carinata seed losses both before and during harvesting in July 2008.

2. FIELD DESCRIPTION

The test was carried out during the first week of July 2008 on a proof field managed by CRA-CIN through the collaboration with the Consorzio Agrario Provinciale of Ravenna, in Bizzuno (RA).
The selected field was a total area of 2.4 ha, regular shaped, and located on a plain. It was divided into three plots. On each of the plots, three different Brassica Carinata varieties (with different crop cycles and different harvest times) were planted in order to follow their growth. "ISCI7" was the variety tested by CRA-ING and it was sown in the first days of November 2007. The main crop data are provided in the Table 1.

Table 1. Main features of the proof plot

Field characteristics	Value
Length (m)	256
Width (m)	12,4
Area (m^2)	3174,4
Variety	ISCI7
Inter-row sowing (cm)	15
Sowing density (kg/ha)	8
Sowing date	03/11/07
Harvesting date	01/07/08

The agronomic aspect was carried out by CRA-CIN, whereas the surveys conducted by CRA-ING began in April 2008 during the period of full Brassica Carinata growth (Fig. 1).

Figure 1. Crop at the survey time of 08/04/2008

At the harvest time (01/07/08) (Fig. 2), the Brassica Carinata plantation did not show significant allotment, but only light inclinations in those areas with growth of siliquae. Until some weeks before harvesting (Fig. 3), the crop was standing without allotment. The average height of this plantation was 1.68 m, and the plot density 54.2 plants/m^2 (uneven distributed).

Figure 2. 01/07/2008: crop condition

Figure 3. 06/06/2008: crop condition

For the evaluation of the pre-harvest seed losses, proof areas were located in the whole field. In

contrast, for the evaluation of losses due to the machine, proof areas were located in specific points of the machine path in order to monitor the losses caused both by the threshing and cleaning and the head.
The New Holland CX 8060 combine harvester (Fig. 4 - 5) was used for the Brassica Carinata harvest, and its main characteristics are given in the following table (Table 2).


Figure 4. The combine harvester at work


Figure 5. Unloading operations

The main aspect to consider is the use of a traditional wheat head in the combine harvester employed in the proof; which is very strange considering the specific heads available on the market for Brassicaceae (rape) that are characterized by vertical separating blades, blade advancing, etc.
Apart from usual adjustments for typology (ripening, shape and seed size) and the condition of the crop (allotment and infestation level), the machine was not otherwise internally modified. It was provided with both a traditional threshing system made up of a thresher and threshing drum in a transverse position with respect to the product flow and with a separating system based on oscillating straw walkers.
Among the specific features of the combine harvester, there was a thresher diameter of 0.75 m, bar number (10) and the placement of an auxiliary rotating separator between the main thresher and the minor separation apparatus.
The oscillating screens for cleaning are formed by a (concave) pressed channel plan preparer and a pre-cleaning sieve that is adjustable (by a lever) at the rear of the combine.

The recovery of incompletely threshed grain takes place by the means of a double-dedicated lateral beater.

Table 2. Main features of the combine harvester in use

Characteristics	Value
Manufacturer	New Holland
Model	CX 8060
Power (kW)	245
Type/ Straw-walker number	traditional/6
Working width	6,2
Head	Wheat

3. MATERIALS AND METHODS

3.1 Pre-harvesting Surveys

At harvest time, the "*ISCI7"* variety was characterized by its uneven degree of growth, especially for the density of plants, in that tall plants (more developed) covered the smaller ones. Before harvesting, samples were taken in the areas of greater growth and a higher density of plants in order to quantify the seeds and siliquae on the ground. These samples were performed by identifying areas of known surface, noting the presence of any siliqua and seed on the ground and then, the whole vegetative part was picked up from the ground and placed on gatherers that were arranged on bolts in order to get the seeds back during the operation.
Thanks to frames used for fixing the sampling areas, it was possible to precisely establish the location of work areas in order to know which seeds dropped on the ground due to the dehiscence process and climatic effects.
According to the survey technique, a bolt was arranged on the field and plants were cut off just above neck height without causing the detachment of siliquae. The bolt was subsequently moved, and all of the product that fell down was placed in bags. In addition, the seed loss harvested in the survey phases were placed in bags.
Both the grain and the biomass were evaluated by their theoretical production. The former, by separating seed from the siliquae with the use of sieves following the ISO 3310-1 and ISO 3310-2 regulations, whereas the latter provided some interesting data for some of the areas surveyed for which the average production was 5.2 t/ha (Table 3). It was also possible to understand how the density was linked to the biomass productivity as well as the fact that tall plants do not ensure significant production.

Table 3. Theoretical biomass productivity

Samples	Density ($n°/m^2$)	Biomass weight (g/m^2)	Biomass weight (t/ha)	%
1	71	891,60	8,916	57,1
2	55	428,50	4,285	27,4
3	27	241,80	2,418	15,5
Total	153	1561,9	15,619	100,0
Average values	51	520,63	5,206	100,0

3.2 Post-harvesting Surveys

For this phase, the adjustments of some internal devices of the combine harvester were evaluated. These adjustments included turns of the batter, the distance between the thresher and threshing drum, turns of the fan, and the opening of the upper and lower screens of the cleaner. Once the most suitable adjustment for the crop conditions was found, the Brassica Carinata harvest of the proof area began.

The measurements of the losses during harvesting were made on the machine passage of three areas in order to learn separately about the losses caused by the head, those due to the threshing and cleaning, and those due to the intersection among operations. The first two monitoring points of the machine were at the lateral sides of the head and at the central part of the machine underneath where the by-products unload. In particular, on the left lateral zone of the head, the area that was monitored included the area between the lateral separator and the area where the left wheel of the machine passed. On the right lateral zone of the head, the zone delimited by the right separator was monitored.

The third monitoring point was by the central zone delimited by the wheels of the combine harvester in order to have data on the head, threshing, separating and cleaning losses.

The above-mentioned surveys were directly made on the ground surface (Fig. 6), by a metal structure (1 m^2 of 10 cm x 10 cm metal mesh), recording both the seed quantity and whether the siliquae was intact or partially open.

Figure 6. Post-harvest surveys

4. RESULTS

The conducted surveys determined that grain production, on a theoretical basis, of the whole plant was equal to 8.43 t/ha, of which 62% (61.68%) was represented by vegetative biomass and 38% (38.32%) by grain.
Before the use of the combine harvester, some surveys were carried out in order to evaluate seed losses not due to the unit.
In Table 4, the results of the five surveyed areas are given, with a theoretical average production of 3.23 t/ha.

Table 4. Theoretical productivity from surveys conducted on 1 m^2 samples

N° samples	Seed productivity (g)	Density (plants/m^2)	Plants height (m)	Productivity (t/ha)
1	331,4	71	1,55	3,31
2	311,6	55	1,62	3,12
3	212,4	27	1,71	2,12
4	363,2	73	1,69	3,63
5	394,8	45	1,84	3,95
Average values	322,68	54,2	1,68	3,23

As already described, before harvesting, some internal adjustments to the combine harvester in order to constrain losses and damages both to the grain and to the by-products, were carried out. The best combination of adjustments (Table 5) was used for subsequent tests.

Table 5. Main adjustments of the combine harvester in surveys used

Machine-member	Parameter	Value
Beater	Rpm	650
Counter-beater	mm	54
Fan	Rpm	570
Upper sieve adjustment	Opening (mm)	3
Lower sieve adjustment	Opening (mm)	1,5

Other data concerning the contaminant content, the weight of 1,000 seeds (by the means of a certified electronic balance), and the percentage of ripe and unripe seeds by weight (Table 6) were collected.

Table 6. Key quality aspects of the grain harvested

Characteristics	Value
Contaminant (%)	1,2
Weight of 1000 seeds (g)	4,6
Degree of ripening (%)	86,5
Unripe seeds (%)	13,5

As shown, the percentage of unripe seeds was quite high (13.5%): a degree of ripening lower than 90% would suggest a slightly earlier harvesting which, however, has not significantly impacted on the test.

The quantification of pre-harvesting losses was conducted according to the methodology previously described. The value for the average pre-harvest loss of 0.010 t/ha was derived from the average of the surveyed areas, and the detailed values for each area are given in Table 7.

Table 7. Pre-harvesting losses evaluations

Samples	Seed loss (n°/m^2)	Seeds weight (g/m^2)	Seeds weight (t/ha)
1	165	0,76	0,008
2	300	1,38	0,014
3	170	0,78	0,008
Average values	212	0,97	0,010

Greater losses were found in the second sampling point corresponding to the area with a good plants growing together with tangled plants.
From the harvester monitoring (at both the sides of the head and at the by-product area), it was possible to establish the average loss per surface vessel (Table 8).

Table 8. Harvesting losses: areas evaluation (3 samples on average)

Survey area	Seeds (n°/m^2)	Seeds (g/m^2)	Harvesting losses (t/ha)
Central	1173	5,4	0,054
Left side	935	4,3	0,043
Right side	2526	11,6	0,116

The surveys at left side of the head show the seed loss due to it, whereas the central area represents the total of head losses together with threshing, separating and cleaning losses, equivalent to 0.11 t/ha (0.3% of the theoretical production), denoting a good machine performance.
The surveys at the right head side observed the separating operations area. The separation by rubbing action with wheat head separators causes an increase in loss of 0,073 t, that is more than twice what recorded on the opposite side of the head, corresponding to about 63%.
Although the amount of the average loss is rather moderate (48.5 kg/ha), the increase due to the separating rows is quite considerable (58%). If we reduce this amount by the 0.10 t/ha that was considered lost in the phase preceding harvesting, we have a loss of 40 kg/ha.
The biomass production of over 5 t/ha is extremely indicative as it includes the products that are difficult to harvest like siliquae and branches.

5. CONCLUSIONS

Thanks to an experiment conducted on Brassica Carinata harvesting, it was possible to evaluate the use of a traditional wheat combine harvester with no specific modifications.
At the harvest time, though the crop had reached a good degree of growth (the average plantation height was over of 1.50 m), the plants were not particularly tangled and it was thus possible to separate the rows from one another.
Losses due to different separating operations (>50%) were significant, especially with plants with a high degree of growth that caused the entanglement of the upper branches. The rubbing

action seems to be the main cause of siliquae detachment, with the most opening for the ripest seeds, in spite of the natural Brassica Carinata resistance to the dehiscence process.
The head losses represented 70% of the total losses. In the experiment carried out, the head losses were due to both their destruction by the pick-up reel and the limited distance between the Archimedean screw and the blade (characteristic of wheat heads), which caused the siliquae to fall on the ground without getting picked up.
The threshing, separating and cleaning systems showed a good overall performance with no internal adjustments, allowing a losses and contaminants reduction in the harvested grain.