SEED LOSSES EVALUATION DURING HEMP HARVESTING WITH A MODIFIED COMBINE HEADER

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ABSTRACT: This work, carried out at Research Centre for Industrial Crops of CREA in Rovigo, aimed at assessing the performance of a modified combine header and seed losses during late harvest of 5 hemp varieties. The renewed interest in Italy for hemp cultivation is aimed at seed production unlike the traditional cultivation aimed at fibre. However, it must face the lack of monoecious varieties suitable for Italian environment. In the case of dioecious varieties, traditionally cultivated in Italy for fibre production, the high crop height makes it difficult the mechanical harvesting with conventional combines. Similarly, the uneven height recorded in the case of imported varieties for seed production, requires adjusting continuously the height of the combine header. So, modified combine headers capable of be moved upwards and downwards by a lift have been developed. The aim is to avoid the risk of possible clogging of threshing apparatus introducing big pieces of stalks. Moreover, in this way, the stalks can be harvested separately in order to increase the income for farmers. In view of valorise the whole plant, as multipurpose crop, the right harvest time should be a trade-off between seed yield and fibre quality. Early harvesting guaranties a good fibre quality but causes also the harvest of seed not completely ripened. On the contrary delaying the harvest reduces the seed yield due to seed loss for dehiscence. In addition to losses for dehiscence prior to harvest, the trials aimed at distinguishing the loss incurred during harvest attributable both to crop disturbance by combine header and to the setting of the combine's threshing and separation elements.
Keywords: hemp harvesting, oilseeds, fibre, losses

1 INTRODUCTION

In Italy there is an increasing interest around hemp for its economic potential because of a new law for the promotion of the cultivation and the agro-industrial chain of hemp (Law no. 242 from 2 December 2016).

It is a renewed interest since hemp has been cultivated in the past on great areas both in the north and in the south of Italy: in 1940s Italy was the main European producer with about 90,000 hectares.

The varieties cultivated in the past were selected for fibre production for textiles and ropes manufacture. With the introduction on the market of cotton and the synthetic fibres hemp cultivation was gradually abandoned [1].

Unlike the traditional cultivation, the renewed interest is aimed at seed production for new different products (foods, bio-construction, thermoplastics, cosmetics, medical etc.). The varieties traditionally cultivated in Italy were exclusively dioecious varieties selected for fibre production. Consequently, the new production destination must face the lack of monoecious varieties suitable for Italian environment [2].

In the case of dioecious varieties, the high crop height makes it difficult the mechanical threshing with conventional combines. Similarly, the uneven crop height recorded in the case of imported monoecious varieties not selected for Italian environment, requires adjusting continuously the height of the combine header.

So, modified combine headers capable of be moved upwards and downwards by a lift have been developed [3,4].

The aim is to avoid the risk of possible clogging of threshing apparatus introducing big pieces of stalks. Moreover, in this way, the stalks can be harvested separately for fibre recovery in addition to seeds in order to increase the income for farmers.

In view of valorize the whole plant, as multipurpose crop, the right harvest time should be a trade-off between seed yield and fibre quality. In traditional hemp for fibre production, harvesting is carried out at full flowering when bark yield reaches its maximum and fibre quality is high.

Postponed harvesting time until seed maturity increases lignified fibre [5].

In dual-purposes hemp, early harvesting guaranties a good fibre quality but causes also the harvest of seed not completely ripened. Delaying the harvest increases the stem yield but can reduce the seed yield due to seed loss for dehiscence.

Infact, hemp is very sensitive to seed loss by the wind and as soon as plant reaches maturity dehisce easily [6].

In order to identify the cause of, and quantify contributions to seed loss during mechanical harvesting of hemp a trial was performed. A combine harvester equipped with a modified wheat header capable of be moved upwards and downwards by a lift was tested on 5 hemp varieties, cultivated each on an average 700 m^2 area, namely: Carmaleonte, Santhica, Codimono, Carmagnola Selezionata (C.S.) and Futura 75.

2 MATERIALS AND METHODS

2.1 Crop and combine harvester characteristics

The study was conducted in October 2018 at the Research Centre for Industrial Crops of CREA in Rovigo (Northern Italy). The Rovigo Research Centre is focused heavily on hemp. Its mission is to grow a wide variety of strains, develop rapid screening tests for cannabinoids, and breed specific cannabis phenotypes for medical use.

The test was carried on 5 hemp varieties cultivated each on an average 700 m^2 area, as reported in Table I.

Table I: Hemp varieties analyzed, origin, type and area cultivated.

Varieties	Origin	Type	Area (m^2)
Carmaleonte	IT	Monoecious	788.8
Santhica	FR	Monoecious	844.8
Codimono	IT	Monoecious	744.4
C.S.	IT	Dioecious	761.6
Futura 75	FR	Monoecious	450.3

Pre-harvesting measurements were performed to determine the average crop height, inter-row and intra-row spacing and plant density.

An axial-flow combine harvester (Case IH Axial-flow 2388) was used for the harvest tests. The combine was equipped with a modified wheat header capable of be moved upwards and downwards by a lift in order to avoid the risk of possible clogging of threshing apparatus introducing big pieces of stalks (Figure 1).

The lift from 0.70 m can rise up to 3.30 m with a maximum cutting height of 2.45 m. The combine header has a working width 5.80 m and features a revolving reel with three arms 0.80 m each. The feeder throat has 1.07 m width and 0.6 m height.

Figure 1: The combine harvester equipped with a modified wheat header used for the test

2.2 Seed yield and losses evaluation

Three possible causes for seed losses were assessed:

A. Seed losses due to dehiscence;
B. Seed losses due to the inefficient setting of the threshing elements;
C. Seed losses due to plants disturbance by the harvesting header.

A-losses occurs before starting harvesting, while B-losses and C-losses occur during the mechanical harvesting.

A-losses (dehiscence) were assessed vacuuming up and weighing hemp seeds fallen on the soil before starting the harvest in three $1m^2$ plot randomly chosen for each variety (Figure 2).

B-losses (inefficient setting of the threshing elements) where assessed collecting all the threshing residues discharged from the combine moving forward 10 meters in three replicates. The threshing residues were collected in a sheet attached to the rear part of the combine (Figure 3).

Figure 2: Seed losses due to dehiscence evaluation

C-losses (crop disturbance by harvesting header) were calculated as difference between total losses evaluated after harvesting (that include all 3 types of losses) and A-losses and B-losses. Post-harvest losses were evaluated vacuuming up and weighing hemp seeds in three $1m^2$ plot randomly chosen. It was possible to assess C-losses only for Carmaleonte variety.

Figure 3: Evaluation of seed losses due to the inefficient setting of the threshing elements

All the material collected in A and B was processed as follow:

1. Drying in a ventilated oven at 105 °C;
2. First separation step into a "seed blowing machine" in order to separate seeds from soil and from empty seeds (Figure 4);
3. Manual sieving with sieves with decreasing mesh;
4. Weighing of seeds.

Figure 4: "Seed blowing machine" to separate seeds from soil and from empty seeds

Seed yield for each variety was obtained by weighing the seed harvested in each plot. In order to completely

empty the hopper of the combine it was vacuumed at the end of each harvested area (variety).

After harvesting the average cutting height was assessed, performing 50 randomly measures per plot.

3 RESULTS AND DIS CUSSION

Pre-harvesting measurements permitted to assess the average crop height and plant density (Table II).

High variability was found in plant height within the varieties. The maximum variability (2.70 m range) was found for C.S. variety that ranged from 1.40 m up to 4.10 m that was the maximum height recorded in absolute among all the varieties.

The minimum range was found for Santhica variety (1.65 m) which reached the lowest maximum height (2.65 m).

On average the variability among the varieties was about 1 m. The sole dioecious variety analyzed C.S. showed the highest average height (2.84 m), confirming its aptitude to produce more biomass and fibre. Carmaleonte variety showed the smallest average height (1.83 m).

Although the modified header utilized for the tests was able to work accordingly to the crop height, the uneven crop height forced the driver to work at the minimum height of the lowest inflorescence, introducing big pieces of stalks (Figure 4). The cutting height was on average half of the plants height (Figure 5).

Table II: Crop density, average, min and max height

Variety	Density (n/m^2)	Average height (m)	Min (m)	Max (m)
Carmaleonte	52.5	1.83±0.46	1.15	2.87
Santhica	70.0	1.92±0.50	1.00	2.65
Codimono	57.5	2.51±0.73	0.90	3.30
C.S.	67.5	2.84±0.81	1.40	4.10
Futura 75	92.5	2.42±0.64	1.10	3.20

Figure 4: Combine header working on C.S. variety at its maxim height

The harvesting was performed very late on October 19th 2018. All the varieties of hemp were in advanced ripening stage and consequently seed losses for dehiscence were very high. (Table III).

The highest losses for dehiscence were recorded for Codimono variety. Except for Carmaleonte, the losses for inefficient setting of the threshing elements were low and less than 10 kg per hectares. In this regard, it should be pointed out that Carmaleonte was the first variety harvested, after that the threshing and the cleaning apparatus were properly adjusted.

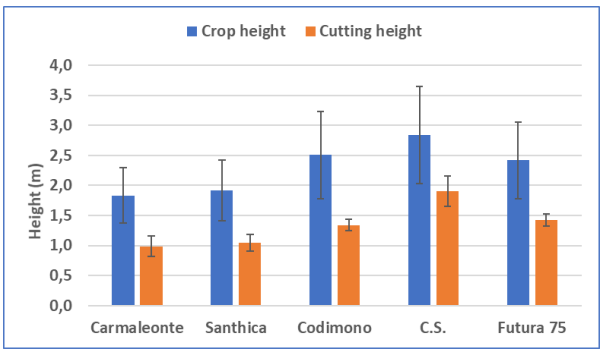

Figure 5: Crop height and cutting height

Seed losses due to the disturbance of the header during harvesting contributed for 9% of the total losses of Carmaleonte variety (73% by dehiscence, 18% by inefficient threshing).

Seed yield were very low. In the case of Santhica and Codimono the seeds harvested were less than one third of the losses. In the case of Carmaleonte we were able to estimate the theoretical seed yield as sum of the real yield plus the three types of losses.

Table III: Seed yield and seed losses for dehiscence (A), for harvesting (B) and for crop disturbance by harvesting header (C)

Variety	Seed yield (kg/ha)	A losses (kg/ha)	B losses (kg/ha)	C losses (kg/ha)
Carmaleonte	172.2	127.9	31.3	16.3
Santhica	33.1	101.9	6.9	n.a.
Codimono	72.3	201.4	2.3	n.a.
C.S.	141.8	67.4	9.4	n.a.
Futura 75	111.0	99.0	4.7	n.a.

4 CONCLUSIONS

The trial was performed in not ideal conditions. All the varieties of hemp were in advanced ripening stage and consequently seed losses for dehiscence were very high. Nevertheless, some useful insights were obtained.

From mechanical point of view, the modified combine header utilized for the tests was able to work accordingly to the crop height, but the uneven crop height forced the driver to work lowest causing the introduction of big pieces of stalks. Anyway it appears a quite simple mechanical solution that can be applied to conventional combine harvesters with affordable costs.

In view of a dual purpose valorization of seeds and fibre, the agronomy practices should be improved. First of all, the harvesting time should be a trade-off between seed yield and fibre quality. The harvesting should be done prior the complete ripeness using after a drying system for seeds. Seedbed preparation, fertilization, time and density of sowing should be investigated in order to obtain a more homogeneous crop height.

Genetic improvement is required in order to obtain dual purpose varieties more suitable for Italian environments.

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