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DEVELOPMENT OF A SPECIAL COMBINE HEADER FOR HARVESTING CANOLA

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ABSTRACT

The objective of this research is to develop, fabricate and test a combine header to suit canola harvest and to reduce the header grain losses.
The developed header was fabricated at the AboKeer factory in Alex, and tested in Nobaria farms. The proposed header unit was designed and fabricated after considering most of the criteria that affect the canola harvest operation. The job of the header unit starts after the canola plant being riped and cut the canola stem before the combine reel touch the plants. The developed header unit consists mainly of three parts: the frame, two cutterbar (horizontal and vertical) and power transmission.

The horizontal cutterbar has forty fixed knifes (76.2 mm) and forty movable knives, eight-knives holder and fixed on the cutter bar holder. The cutterbar is powered mechanically through V. belt from the main cutterbar power system and it moves at a speed of 1.5 m/s with a knife stroke of 76.2 mm. The horizontal cutterbar attached to a special frame. The vertical cutter bar has two bar each one has twenty-eight knives (50 mm) work as double acting knife. The vertical cutterbar is powered by 12 v electrical motor. The propose of the vertical cutter bar is to cut the interaction between plant branches in the right side of the combine above the outer shoes (crop divider) to help the cut crop to inter the combine without drag the standing plant.

The field test showed that the recommended forward speed is the fourth speed 4 km/h which gives the best results in terms of higher field capacity (1.67 fed/h), and the best performance is in terms of less grain losses, best handling of the crop inside the combine and best speed for the combine maneuverability under the test condition of this study.

Modifying the combine header affect each of field capacity, harvesting rate, grain losses but not cleaning efficiency. Using the new header gave the combine better performance. Using the new header had its evident impact on the amount of increased field capacity about (11-20 %), decreased the total grain losses about 8.8%. The cleaning efficiency was about 85.9% at the recommended forward speed.

INTRODUCTION

Canola (Rapeseed) is one of the most important oil seed crops in the world. Its production over the past decade has grown much faster than any other vegetable oil crop. Canola oil is one of the better plant oil in term of human feeding which have only 6 % saturated fat. Egypt grows Canola (free of erucic acid in oil and glucosinlates in the animal feed “kosp”) as winter crop. Canola is riped when the stems color and seeds became dark brown. Seed moisture should be lowered to 9-11 percent if it is to be directed combining and stored for a long.

Kearney and Temple (1991) stated that canola is the name for edible oilseed rape. The canola plant resembles a turnip plant in the fall (without the large root). When the plant acquires 6 to 8 leaves and reaches a height of 5 to 6 inches, it has adequate root reserves for surviving winter dormancy (24°F). In late winter, the plant develops new leaf growth and begins to show a single stalk. Mustard-yellow flowers soon appear. In June, the plant has tan stems and seed pods, and is 4 to 6 feet tall. Seed pods are two inches long with 15 to 20 seeds per pod.

Wysocki, et al., (1996) mentioned that two methods of harvesting canola are available to producers. Direct combining or swathing followed by combining. Direct combining is less costly than swathing, but is more risky because of potential shatter loss during the dry down period. Swathing increases harvest costs, but reduces the risk of shatter loss and makes harvest more timely.

Baily (1980) stated that losses at cutter bar during harvesting rapeseed was about 265kg/hectare and an-average of 70 % of these occur up to and at the point where the crop enters the combine. Crops can be very tangled or tending to lean in one direction and losses can be minimized if the standing crop enters the combine pods first rather the stalks, when there a tendency to shake the seed out in front of the harvester.

Bahanassy (1992) harvested canola by two different combines. He stated that the total harvesting losses reached 24% when harvesting by conventional combine, which means that we loss quarter of the canola production in the ground. The header loss was 50 % of the total combine losses during harvesting canola.

Berglund et al., (1999) stated that canola has become a major economic oilseed crop in North Dakota and northwestern Minnesota in recent years. However, many growers are relatively inexperienced with canola production and harvesting. Many new growers have limited experience with the crop. Proper harvest management in terms of selecting the proper maturity stage for swathing and combining are very important. As a canola crop nears maturity, it may ripen very quickly. Selecting the correct time to swath and combine canola demands more observations and care. Swathing canola at the optimum stage of ripening reduces green seed problems and seed shatter losses and ensures the quality required for top grades and prices. Inspect fields every two to three days when there is some color change in the first formed pods on the bottom of the main stem.

Robertson and Cawley (2001) stated that canola is more risky than other crop enterprises (eg. wheat) where yield and quality are often inversely related, which confers some stability to profit. They decided that methods of harvest management need to be designed for the lower-yielding and more rapidly maturing crops in the northern region of USA in order to minimize harvesting losses.

Nyborg, et al., (2002) mentioned that the standard combine had bout 30% less capacity than the modified combine in dry Candle canola, however, modifications increased grain damage. The capacity increase in Candle anola was due to installing wire mesh on the straw walkers, and was not a result of modifying the cylinder, concave or shoe. This latter increase in canola can be expected only in very dry crops where straw breakup is excessive. They also stated that the combine settings for candle canola, modified standard showed be as follows: Cylinder Speed 800 - 500(rpm), Concave clearance; Front 25-18 mm and Rear 6 mm, Fan Speed 500 -580(rpm), Chaffer, Front 13-19 mm, Rear 12 –13 mm, Sieve 3 mm.

Ohio Agronomy Guide (2002) mentioned that canola is riped when plants turn a straw color and seeds become dark brown. This occurs approximately 1st July for winter varieties. Combine cylinder speed should be 1/2 to 3/4 that used for wheat. Seed moisture should be near 11 percent for direct combining. Seed moisture should be lowered to nine percent if it is to be stored for a long. Because canola shatters easily (1 to 5 bushel/acre [bushel =22.73 kg]) at harvest.

Lotfy et al., (2002) stated that the maximum rate of seed losses of the cutter bar only reaches 14.9 % during harvest canola crop. They mentioned to the high losses that occur in manual harvesting. They concluded that the canola crop is difficult to be harvest manually due to interaction between plant branches.

Zavodny et al 2006. measured harvest loss for 17 combines during the 2005 harvest of winter canola in Oklahoma. Losses were measured for 15 combines that directly harvested canola fields and for two combines harvesting canola that was previously swathed and placed in windrows. Processing loss for the swathed observations averaged 39 kg/ha (35 lbs/acre) while the direct harvested observations averaged 103 kg/ha (92 lbs/acre). Total combine harvest losses averaged 14.9% and ranged from 3.5 to 30%.

Canola crop can help to reduce the oil gap in Egypt for many reasons: It can grow in new reclamed areas. It does not comparators with winter crops such as wheat, barley or alfalfa. Also it has higher content of oil in seeds 45%. On the other hand Canola is difficult crop to harvest because it is tall, branchy and easy to shatter. Developing of any proper machinery techniques to optimize the canola harvesting is a vital subject to be investigated. Therefore the objective of this research is to develop, fabricate and test a canola header to suit the exiting combine and to reduce header grain losses.

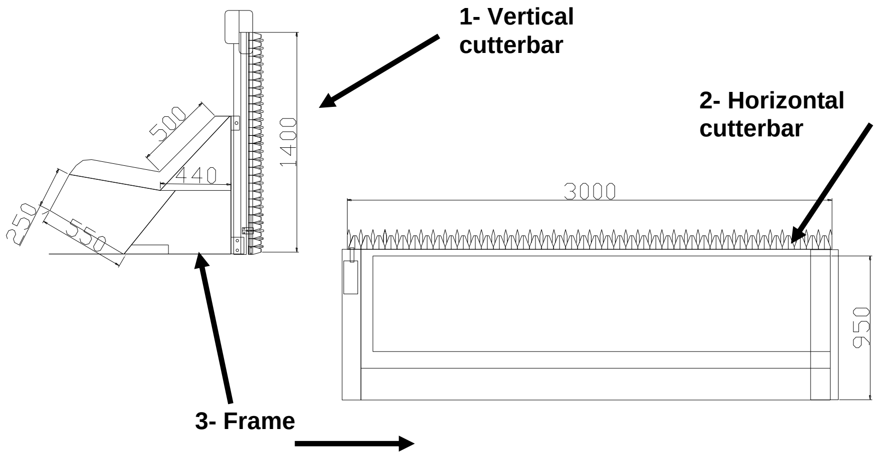
MATERIAL AND METHODS

1-The developed header:

The proposed header unit was developed and fabricated after considering the criteria that affect the canola harvest operation (cutting force of stem, interaction between plant branches). The developed header unit consists mainly of three parts: the frame, two cutterbar (Horizontal and Vertical cutterbar), and power transmission system. The developed unit has 3-m long as shown in Fig. (1).

1-Frame: -

The frame was developed and constructed to suit fixing all machine components rigidly and safely. The frame is made of steel square hollow bar 80x80 mm and 3-m long. The cutterbar with its holder are attached to the frame by means of bolts. The header was attached to the conventional combine header (Fig.2) by means of the special arrangements.



Dim. In mm

Fig. (1): Vertical and horizontal cutterbar of the developed header

2-Cutterbars: -

The fabricated header unit has two cutter bars, The horizontal cutterbar has forty fixed knifes (76.2 mm) and forty movable knives, eight-knives holder and fixed on the cutter bar holder. The cutterbar is powered mechanically through V. belt from the main cutterbar power system and it moves at a speed of 1.5 m/s with a knife stroke of 76.2 mm. The horizontal cutterbar attached to a special frame.

The vertical cutter bar has two bar each one has twenty-eight knives (50 mm) work as double acting knife. The vertical cutterbar is powered by 12 v electrical motor. The propose of the vertical cutter bar is to cut the interaction between plant branches in the right side of the combine above the outer shoes (crop divider) to help the crop to inter the combine without drag the plant outside the outer shoe.

Fig. (2). The developed header attached to combine

3-Power transmission system:-

The power is transmitted for the horizontal cutterbar from combine header itself, but the vertical cutterbar the power is provided through a 12 V electrical motor wired to the combine battery. The specification of the electrical motor is listed in Table 1:

Specification	Nominal voltage	power	current	Continuous torque	Breakaway torque	weight
	12V	400 W	50A	1.2 Nm	6.4 Nm	3.1 kg

The developed header was attached to the combine. The main specifications of the combine is shown in Table 2.

Table (2) The main specifications of the tested combine :

Type	Conventional Multi-crop combine (Claas)
Model	Dominator 68S
Width of cut, m	3
Drum types	Spike tooth
Drum diameter, m	0.45
Drum length, m	1.06
Engine type	Diesel engine
Power, hp	115
No. of cylinders	6
Overall dimension Width over tires , m	 2.62
Height, m	3.54
Length, m	9.7
Mass, kg	6930

Tests and evaluation were carried out on Cotton, Fiber and Oil Counsil farm and Youth Graduated Farms, Nobaria, Behara Governorate during 2003-2004 harvesting season. The fabricated header was evaluated and its performance was compared with the conventional combine method. In the present study, harvesting was done early morning. Four different forward speeds were used in this study. The average forward speeds were 1.6, 2.5, 3.3 and 4 km/h. Each experiment was repeated for three times. The cutting height was kept at rate of 250 mm through the whole experimental work.

The cultivated canola variety was Bactool. The major dimensions of canola plants were measured and their mean and standard deviation were calculated. The measurements are listed in Table 3.

Table 3: Test conditions:

	Crop condition	
1	Crop type and variety	Canola, Bactool
2	Av. Plant height, cm	160
3	Seeding	Mechanical by seed drill, 3 Kg/fed
4	Av. Plants /m^2	50
5	Av. Stem diameter, mm	18
6	Av. Moisture content, % Grain Straw	 11.5 19.85
7	Av. Crop yield, kg/fed. Grain Straw	 1250 2600
8	Grain / Straw ratio	1-2.1
9	Cutting force for stem, N	302
9	Grain crushing force, N	15.02
10	Capsule crushing force, N	5.40

The field tests were accomplished by following the RNAM 1983 and ASAE standard code S396.2 and S343.2, 2004 to obtain the following measurements:

Field capacity refers to the estimated area that the combine can accomplish per hour of time. The following equation could be used to calculate the theoretical field capacity:

$$F.C_{th}.= VW /4.2$$

Where:

$F.C_{th}.$ = Theoretical field capacity, fed/h.
V = machine working speed, km/h
W = machine working width, m

The actual field capacity was determined using the following formula:

$$F.C_{a}.= 60/(T_u+T_l)$$

Where:

$F.C_{a}.$ = Actual field capacity, fed/h.
T_u = The utilization time per feddan in minutes.
T_l = The summation of lost time per feddan in minutes.

Crop yield

Three samples were collected using one square meter wooden frame in three randomly selected areas of the standing crop. A plant collected samples were threshed, separated, cleaned and weighted in order to determine grain / straw ratio and crop yield.

Grain losses

The field tests were conducted to determine three types of grain losses.

1. Pre-harvest losses which included the loss due to natural causes before harvest.
2. Header losses caused by the cutterbar.
3. Processing losses.

Pre-harvest losses were measured by collecting the grains and seed pods laying on the ground by using one square meter wooden frame in three randomly selected areas of the standing crop. Header losses (cutterbar and reel) were measured by by placing two 10*50 cm trays with 2 cm high during combining. Trays were inserted in the interior of each test by sliding them between the canola plant rows (Wysocki et al 1996).

Processing grain losses were measured by collecting the grains from a 10 m long canvas located behind the combine.

The total losses = (header losses + Processing losses)

Cleaning efficiencies (C_E)

Cleaning efficiency is defined as the percentage of the grains to other material than grain (MOG) which consists of mainly chaff and broken straw pieces. And it can be calculated as the following:

$$C_E, \% = (\text{weight of clean grain, kg / weight of total grain sample, kg})*100$$

RESULTS AND DISCUSSION

Results of field tests are presented as indicators of combine performance. The performance of the combine before and after using the new header were tested and evaluated according to the following aspects:

1- Actual field capacity. **2- Grain losses.**

3-Cleaning efficiencies.

To determine the benefit of the new developed header, it was compared to harvesting with conventional combine under the local operating conditions. The purpose of this header is the cut the plants before the combine reel touch it and also the cut the interaction between plants branches to increase the field capacity, cleaning efficiency and to minimize the grain losses.

Actual field capacity at different forward speeds:

The actual field capacity and harvesting rate of the combine before and after using the developed header is presented in Figs. 3&4.

The actual field capacities for harvesting canola crop before using the new header were 0.75, 1.01, 1.35 and 1.53 fed/h. at forward speeds of 1.60, 2.50, 3.30 and 4.00 km/h respectively. The actual field capacities after using the new header were 0.83, 1.19, 1.47 and 1.67 fed/h. for the same forward speed respectively

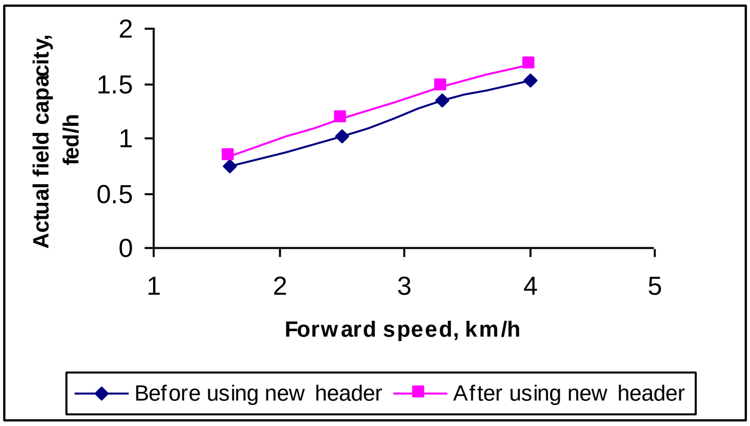


Fig. (3): Field capacity before and after using the new header

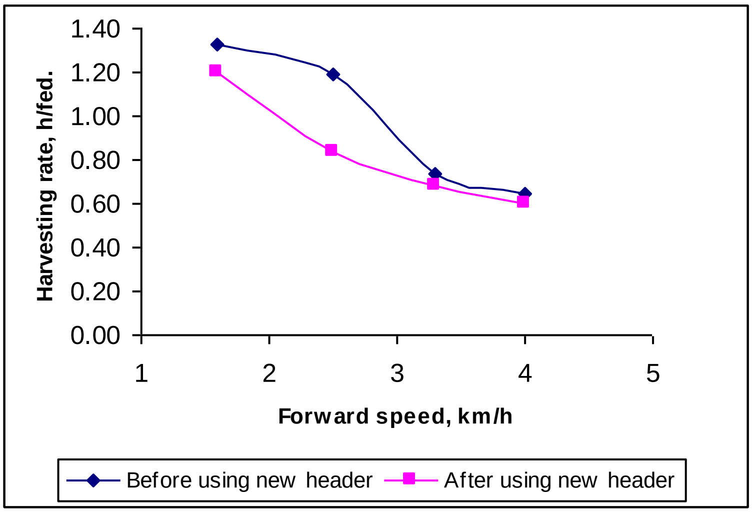


Fig. (4): Harvesting rate before and after using the new header

On other hand, The harvesting rate for harvesting canola crop before using the new header were 1.33, 1.19, 0.74 and 0.65 h/fed. at forward speed of 1.60, 2.50, 3.30 and 4.00 km/h respectively. But after using the new header the harvesting rate were 1.2, 0.84, 0.68 and 0.60 h/fed. for the same forward speed respectively

From the previous discussion, it is clear that the actual field capacity and harvesting rate had significant differerance after modifying the combine. Using the new header increased field capacity by (11-20%)

Grain losses at different forward speed:

Figs. (5)&(6) illustrate the total grain losses before and after using the new header. The total grain losses before using the new header for harvesting canola crop were 17.76, 18.62, 19.91 and 21.29 %. for 1.60, 2.50, 3.30 and 4.00 km/h combine forward speed respectively. On the other hand the total grain losses after using the new header for harvesting canola crop were 9.47, 9.82, 11.06 and 12.07 %. for 1.60, 2.50, 3.30 and 4.00 km/h forward speed respectively.

The total grain losses increased when combine forward speed increased. The above mentioned results show that, the combine has adequate total grain losses after using the developed header for harvesting canola crop. It may concluded that the developed header decreased the average total grain losses by 8.8%.

The cleaning efficiencies

The cleaning efficiencies have no significant difference before and after using the new header. The average cleaning efficiencies for harvesting canola crop before and after using the new header were 90.40, 89.00, 86.30 and 85.60% at forward speeds of 1.6, 2.5, 3.3, 4.00 km/h respectively. Results of cleaning efficiencies showed that the increased of forward speed, reduced the cleaning efficiencies. This may be due to that more material should be handling in the cleaning system. The cleaning efficiencies were low or the material other than grain (MOG) was high because the cleaning fan set to be low to not through more canola grain out of combine.

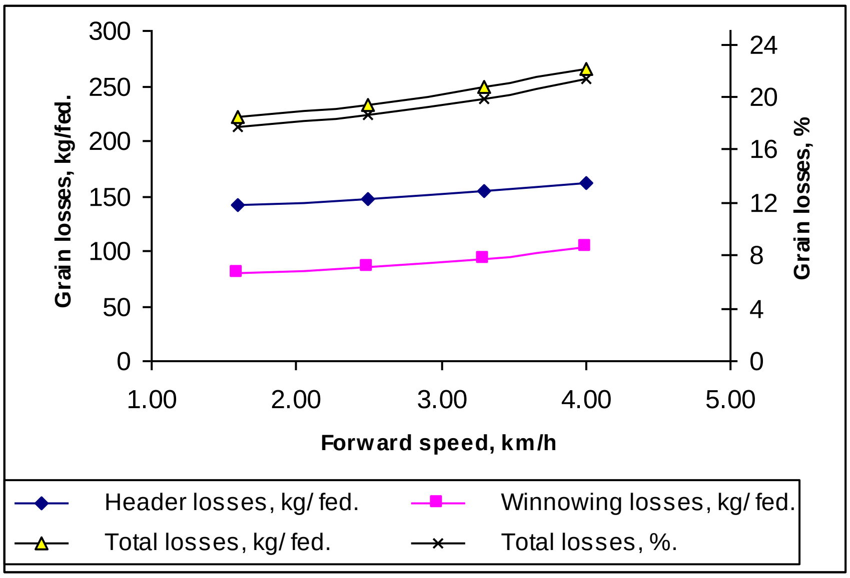


Fig. (5): The different grain losses before using the new header

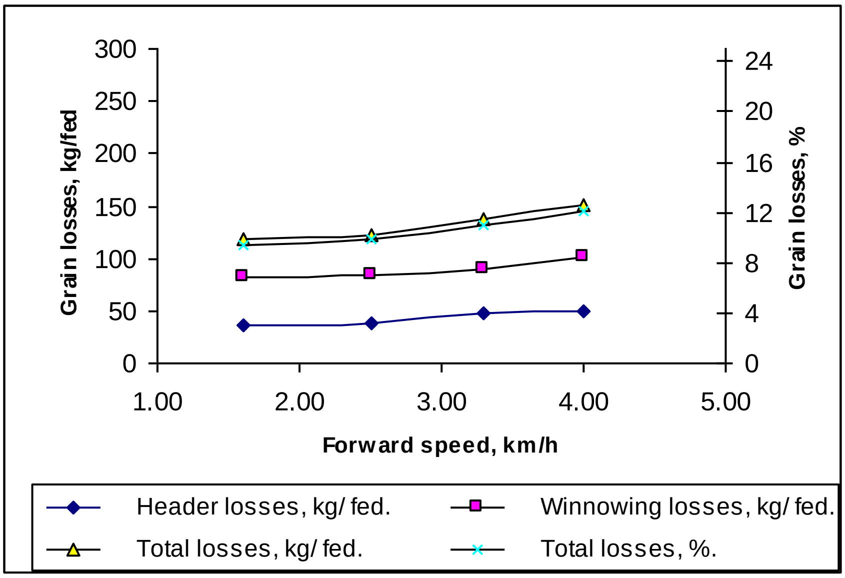


Fig. (6): The different grain losses after using the new header

Conclusion

The conclusion can be summarized as follows:

The proposed header unit was developed and fabricated after considering the criteria that affect the canola harvest operation (cutting force of stem, interaction between plant branches). The developed header unit consists mainly of three parts: the frame, two cutterbar (Horizontal and Vertical cutterbar), and power transmission system.

The field test showed that the optimum forward speed found to be 4 km/h which gives the best results in terms of higher field capacity (1.67 fed/h), and the best performance is in terms of less grain losses, best handling of the crop inside the combine and best speed for the combine maneuverability under the test condition of this study.

Modifying the combine header affected the field capacity, harvesting rate, grain losses but not cleaning efficiency. Using the developed header gave the combine better performance. The using the developed header had its evident impact on the amount of increased field capacity about (11-20 %), decreased the average total grain losses by about 8.8 %. The cleaning efficiency was about 85.9% at the optimum speed.

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تطوير جهاز ضم خاص بحصاد محصول الكانولا

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تعتبر الكانولا من المحاصيل الهامة كمصدر من مصادر الزيوت فى العالم ولذلك سعت مصر الى زراعة هذا المحصول الهام لسد جزء من فجوة الزيوت فى مصر حيث تستورد مصر مايقرب من 90% من احتياجاتها من الزيوت من الخارج.

هدف الدراسة هو تطوير وتصنيع واختبار جهاز ضم يتم تركيبه على الكومباين الذى يقوم بحصاد الكانولا لتقليل فاقد الحبوب الناتجة عن جهاز الضم التقليدى، وتم الأخذ فى الاعتبار الظروف الخاصة لهذا المحصول عند الحصاد حيث أنه شديد الحساسية للانفراط ، فروعه متشابكة، ويتم فقد جزء كبير من الحبوب عند تلامس مضرب الكومباين مع النباتات وأيضا عند فصل النباتات المتشابكة والتى سوف تدخل إلى جهاز الضم عند مقسم النباتات بالكومباين، بالاضافة الى قوة القطع اللازمة لساق الكانولا.

تم تصنيع صدر الحصاد بشركة أبوقير للصناعات الهندسية بالاسكندرية وتمت الاختبارات بمزرعة مجلس القطن والألياف والمحاصيل الزيتية ومزارع شباب الخريجين بمشروع مبارك القومى بالنوبارية.

يتركب جهاز الضم المطور من شاسية، عدد 2 قضيب سكاكين، أحدهما أفقى ويتكون من 40 سكينة ثابتة و40 سكينة متحركة عرض 7.62 سم (3") ويستمد الحركة من جهاز الضم الرئيسى للكومباين، والآخر رأسى ويتكون من 28 سكينة مزدوجة التأثير عرض 5 سم (2") ويستمد الحركة من موتور كهربى موصل ببطارية الكومباين.

أظهرت النتائج أن سرعة تقدم الكومباين (المزود بجهاز الضم المطور) المقدرة بحوالى 4 كم/ساعه اعطت أفضل سعة حقلية فعلية 1.67 فدان/ساعة، بمعدل زيادة يتراوح من 11-20%، كما أدى الحصاد بجهاز الضم المطور إلى تقليل الفواقد الناتجة بالمقارنة بجهاز الضم التقليدى بحوالى 8.8 %، كما كانت نسبة نظافة الحبوب 85.9 % على نفس السرعة.