COMBINE HEADER CONTROL

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ABSTRACT

Combines and reapers harvest the grain crops, the green grass and other similar plants, therefore the cutter bar should be able to cut from 30 to 100 mm above the ground surface. The cutting parts should also be protected from hitting the rocks or the soil. It should also be considered that any crop remains of cutting height on the ground after the harvest are a loss. The muddy conditions found in rice growing area proved difficult, because the cutter could hit the ground when the combine header would sink into the soil. Running the stubble cutter into the soil would cause it to jam or partially plug up, making it ineffective.

The main purpose of this study was to cut the crop at the lowest possible level by manufacturing an automatic control unit which controls upping/downing the combine header, in order to avoid the obstacles which face it when lowering the cutter bar level.

An automatic control unit has been constructed locally at the engineering workshop of Rice Mechanization Center (R.M.C), Meet El-Deeba, Kafrelsheikh Governorate, Egypt during the year of 2006.

The experiments were carried out during rice harvest season of 2007 in order to compare two combine systems for the combine (Yanmar-CA65V) under the same different operating conditions. The first combine has an automatic control unit (combine with control system). But the second combine hasn't an automatic control unit (combine without control system or the conventional combine). All experiments performed at the research farm of Rice Mechanization Center.

The obtained results may be summarized as follows:

1- The optimum operating conditions for the combine with control system are at forward speed of 2.5 km/h and cutting height of 0.05 m.

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2- The optimum operating conditions for the conventional combine are at forward speed of 2.5 km/h and cutting height of 0.10 m.

3- The combine with control system is strongly recommended since it gives lower loss and costs, and higher field efficiency compared to the conventional combine.

INTRODUCTION

Increasing the need for a lower harvester cut in the field even where the straw is to be burned. This may make low level cutting of the straw during grain harvest more reasonable for straw removal as compared to burning the straw ***(Dobie et al., 1984)***. Rice straw has a number of potential uses including fuel for energy production, feedstock for chemicals, feed for livestock, and fiber for erosion control, building materials, and compost ***(yore et al., 2001).***

Nader et al. (2000) studied rice straw utilization by cattle. They reported that animal feeding constitutes the largest current off-field use for rice straw. Rice straw is a low-value feed, but protein content is enhanced by rapid harvest of straw to reduce volatile loss of nitrogen that occurs during extended exposure in the field. ***Tandon and Panwar (1989)*** found that header losses represent 80% of all soybean losses and consisted of 61% shatter loss, 22% lodging and stalk loss, and 17% stubble loss. ***Hill et al. (1998)*** indicated that one possible improvement in the collection of rice straw comes during the cutting process. Standard practice of harvesting rice grain is to cut the plant midway up the stem. The lower portion, known as stubble, is then left standing in the field, while the upper portion is threshed. For enhanced soil preparation and better management of disease and pests by removal of infected material, cutting and removal of the stubble from the field is beneficial. ***McMaster et al. (2000)*** studied optimizing wheat harvest cutting height for harvest efficiency and soil and water conservation. They indicated that managers of harvest operations must balance soil and water-conservation benefits of maintaining sufficient stubble height with the risk of losing grain yield due to unharvested spikes below the combine cutting height. They calculated the relationship between expected harvest losses and conservation of soil and water at various combine cutting heights. The final results indicated that quantifying RFVs at the soil surface and relative evaporation rates showed that combine cutting heights <0.1 m offered little protection from erosive winds for sparse stands with <280 stems m-2. Higher cutting heights of 0.3 or 0.5 m increased protection, especially for sparse stands, but the relative benefits of increasing stem frequencies declined with higher cutting heights. ***Garson and Armstrong (1993)*** carried out ultrasonic base cutter height control. They mentioned that an automatic height control system for use in sugar cane harvesting was designed and tested. A pulsed ultrasonic height sensor was attached to the front of the harvester and connected to a hydraulic height adjustment mechanism on the front wheels. An accept/reject time window was used to distinguish false echoes. Field tests were carried out on burnt cane in the Burdekin region. Results showed that the height control system operates effectively given sufficient time to adjust. Cane loss and fuel consumption were higher and dirt content evaluation proved inconclusive. It is concluded that the automatic height control system assists manual operation to a limited extent dependent upon conditions. ***Mosby (1995)*** mounted an additional sickle bar cutter on the back side of a combine header. The sickle bar was supported by tracking arms and suspension springs allowing the cutter to float along the ground surface while the combine harvester was in operation. ***Murphy (2000)*** carried out a study on stubble cutter on combine. He suspended an additional sickle bar cutter from a conventional combine header simply by hanging it on chains. The simplicity of his design limited its operation because the height of the second cutter could not be easily adjusted. He also reported that running the stubble cutter into the soil would cause it to jam or partially plug up, making it ineffective. The chosen placement of this stubble cutter was not in view of the operator, so keeping the cutter out of the soil was a difficult task, and errors resulted in harvester downtime. ***Yore et al. (2001)*** developed a stubble cutting system for combine harvester. They stated that off-field utilization of rice straw has initiated improvements in straw handling techniques. One possible improvement involves using the combine to increase straw yield, either through ground level harvest or through the attachment of a stubble cutting device operating behind the main header. Alternative designs for stubble cutters were examined and a sickle cutter prototype was fabricated and tested. Also, they added that the stubble cutting system for a combine harvester consists of sickle bar, sickle drive, draper belts and frame. The results indicated that the stubble cutter did increase straw yield compared to standard harvest practice, although the theoretical yield was not achieved. The field capacity of the combine with the stubble cutter was slightly decreased compared to the conventional combine. Cutting lower with the combine header required slowing the harvester speed, decreasing field capacity. ***Lopes et al. (2002)*** carried out optimal header height control system for combine harvesters. They mentioned that the automatic control of header height has been employed in combine harvesters as a means to reduce stubble loss and the risks of equipment damage. State-of-the-art combine harvesters usually incorporate on–off controllers to keep the header at the desired height. The fixed control signals and the relatively broad dead-bands required for stabilization of this type of controller impose serious limitations on the performance of such systems. An alternative control system aiming to improve the performance of combine harvesters in following the soil profile. The final results indicated that the use of the LQG/LTR controller can significantly improve the disturbance rejection capacity of the system. ***Esquivel et al. (2008)*** evaluated the automatic base-cutter control system. They stated that the height control of the base-cutter system requires a lot of concentration of effort from operators. Bad results not only have negative economic impacts, but also environmental impacts due to sucrose losses in the field. Evaluations included field measurements of stool damage, stubble height and estimated losses. Quality data were measured at the mill when possible, as fibre content, CCS, juice purity and soil content. The results of the trials varied slightly with field conditions and operators, but in general showed several benefits with the use of the automated base-cutter control system. Average values showed reduced stool damage by 5.7%; similar soil levels; reduced stubble height by 22.5 mm; and reduced cane losses by 1.7 t/ha. Differences in fibre, CCS and juice purity were small (0.1%) and not statistically significant. Factors influencing the adoption of this technology are discussed. These include not only the economic and environmental impact, but also some social components such as the increasing lack of skilled operators.

The main objectives of the present study may be summarized as follows:

1- To reduce stubble loss (cutting height loss), the environmental pollution due to burning stubble loss, the risks of equipment damage and operator stress.
2- To manufacture a local automatic control unit for controlling upping/downing the combine header to avoid the obstacles which face it when lowering the cutter bar level.
3- To evaluate the combine performance before and after development to compare between them under the same different operating conditions at the same time and to determine the optimum operating conditions.
4- To choose the most efficient and economic harvest system at the lowest loss and costs, and the highest efficiency under the different operating conditions.

MATERIALS AND METHODS

Materials:

The materials and equipments which are used in this study can be indicated as follows:

1. Fabricated an automatic control unit:

The automatic control unit has been constructed locally at the engineering workshop of Rice Mechanization Center (R.M.C), Meet El-Deeba, Kafrelsheikh Governorate, Egypt during the year of 2006.

The automatic control unit is upping/downing header control unit, to protect the combine header especially the cutter bar from hitting the rocks or the soil, that is by using the electronic control.

The upping/downing header control unit in the combine header, as shown in Figure 1, consist of the following main parts:

1- Three upping header sensors;
2- Adjusting header height control sensor;

3- Upping/Downing header control robot;
4- Power supply circuit;
5- Cutting height manual control circuit;
6- Upping/Downing header control circuit and
7- Robot control circuit.

N.B.(nota bene): The combine, used in this study, is small with two rows and has three dividers in the front, so three upping sensors has been fabricated. Each upping sensor fixed on the divider. Consequently the sensors have been distributed on the front of the combine.

Operating method of automatic control unit

The automatic control unit, as shown in Figures 1 and 2, operates as following:

At first, cutting height is adjusted manually by the variable resistor (VRa) which is fixed in the cutting height manual control circuit to determine the required cutting height so that the number of the lighted lambs in the cutting height manual control circuit equals the cutting height in centimeter.

When the upping header sensor hits any obstacle, it gives a signal to generate an electric pulse. This pulse reaches the upping/downing header control circuit which, in turn, gives a signal to the robot control circuit which, moves the arm of the electric motor in the robot to the left in order to push the arm of operating hydraulic lifting pump. Consequently the oil rushes to the hydraulic piston of raising the header which causes the upping of the header. The header will continue rising until the volt coming out of the adjusting header height control sensor equals the volt coming out of the timer circuit; at this time the header stops rising and keep rising until the period on which the timer circuit has been set ends. Then, a signal is generated to the upping/downing header control circuit which give a signal to the robot control circuit which, in turn, moves the arm of the electric motor to the right in order to push the arm of operating the hydraulic lifting pump back to its initial position. Consequently the oil rushes from the hydraulic piston of rising the header to the tank under the effect of the header weight. The header starts to down again to reach the starting position.

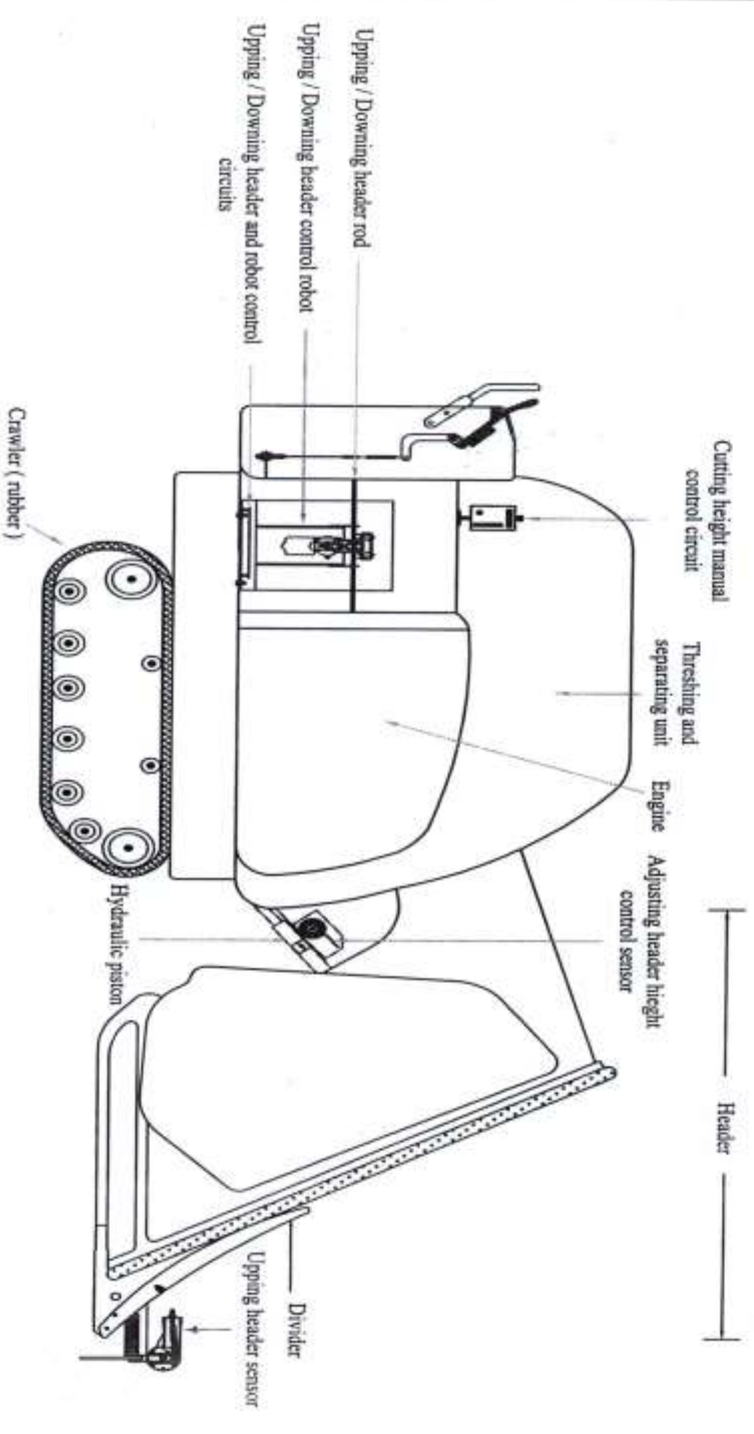

Figure 1: Schematic diagram of the combine (Yanmar-CA65V) with an automatic control unit.

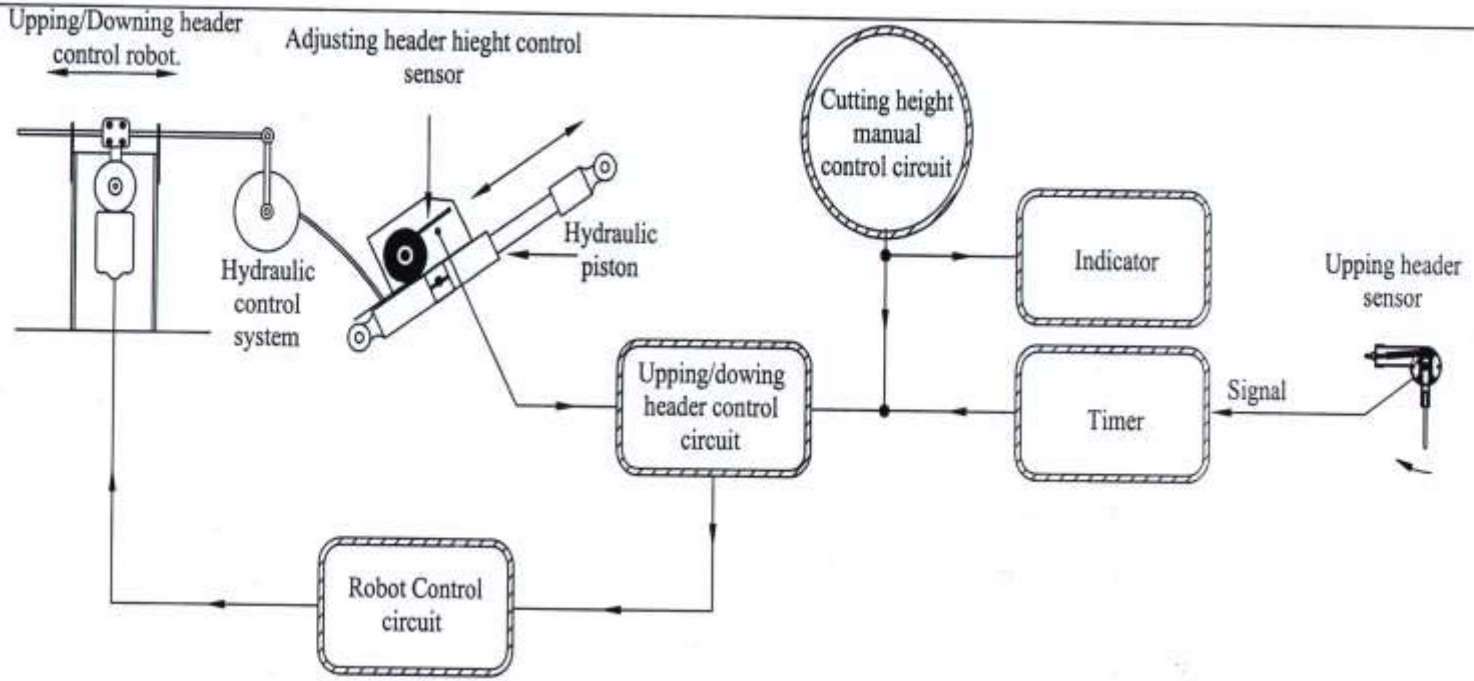

Figure 2: An automatic control unit for the combine (Yanmar-CA65V).

2. Measuring instruments:

2.1. Digital multimeter:

A digital multimeter, Sk6222 model, Japanese made, was used to measure the alternating and direct current input (AC and DC voltage), current (Ampere) and resistance (Ohm).

2.2. Digital vernier caliper:

A digital vernier caliper with accuracy of 0.01 mm was used to measure the different dimensions.

2.3. Measuring tapes:

Two linen tapes; one is 2 m long and the other is 20 m long were used for measuring and determining dimensions.

2.4. Oscilloscope:

Oscilloscope (model 7633) Japanese made, was used for detecting the signal pulses and measure their electric interval. It has been also used to compare between the starting and ending of the generated pulses for the different electric circuit.

2.5. Electrical oven:

It was used for determining the moisture content of both grain and straw. The oven method was used to dry samples for 24 hours at 105ºC.

2.6. Balances:

Two types of balances were used, the first type is an electrical balance with an accuracy of 0.1 gram. The second one is mechanical type with an accuracy of 1 gram.

2.7. Stop watch:

It was used to determine the time in the experiments.

2.8. Fuel consumption apparatus:

The rate of fuel consumption was measured by using a fuel consumption apparatus. Its capacity is 750 ml. It has a reading scale divided into 15 sections. Each section is reading 50 ml.

2.9. Several square frame made from wood:

The frame has the dimension of 1 meter by 1 meter was used to determine total yield.

2.10. Long sheets of canvas:

Canvas sheet of 5 m long and 2 m wide was used to collect the straw behind the combine in order to determine straw yield.

Methods:

The experiments were carried out during rice harvest season of 2007 in order to compare two combine systems for the combine (Yanmar-CA65V). The first combine has an automatic control unit (combine with control system). But the second combine hasn't an automatic control unit (combine without control system or the conventional combine).

The two combine systems were tested at four different forward speeds of about 0.8, 1.2, 1.8 and 2.5 km/h and four different cutting heights of about 0.05, 0.10, 0.15 and 0.20 m at grain moisture content of about 18.13% (w.b.) and straw moisture content of about 30.08% (w.b.) of Sakha-101 rice crop.

The experiment was designed and analyzed a statistically as split-split plot design with three replicates. The combine forward speeds were used as main plot. But, the cutting heights were put in the sub-plot and the sub-sub plot was the combine systems. The area of sub-sub plot was 98 m² (1.4 × 70m). The experimental area was 9408 m² which is equal 2.24 feddan.

All experiments performed at the research farm of Rice Mechanization Center, Meet El-Deeba, Kafrelsheikh Governorate.

Measurements:

1. Moisture content measurement:

Grain and straw samples of 100 grams were dried in an electrical ventilated type oven for 24 h at 105ºC. After this period, the samples were taken and weighed. Percentages of grain and straw moisture content were calculated. All moisture content data given were on wet basis according to the following equation:

$$M_W = \frac{W_1 - W_2}{W_1} \times 100, \% \text{ -- } 1$$

Where:

M_W = The moisture content of sample on wet basis, %;

W_1 = Mass of wet sample, g and

W_2 = Mass of dry sample, g.

2. Straw yield:

Straw yield was determined by dragging canvas sheet behind the combine for a distance of 140 meter long for the undertaken replicates. The collected straw on the canvas sheet weighed, after that determined to the feddan.

3. Field capacities and efficiency:

3.1. Theoretical field capacity:

The theoretical field capacity (Tfc) was calculated by using the following formula ***(Kepner et al., 1982):***

$$Tfc = \frac{V \times W}{4.2}, \text{ fed./h} \text{ -- } 2$$

Where:

Tfc = Theoretical field capacity;

V = The forward speed, km/h and

W = The machine operating width, m.

3.2. The effective field capacity:

The effective field capacity (Efc) was calculated by using the following formula:

$$Efc = \frac{1}{T} \text{ -- } 3$$

Where:

Efc = Effective field capacity, fed./h;

$T = t_1 + t_2 + t_3 + t_4$;

T = The total harvesting time;

t_1 = Operating time (straight time);

t_2 = Time lost for turning;

t_3 = Time lost for repairing and

t_4 = Time lost for adjusting the machine.

The time needed for each experimental plot block treatment was measured by using an ordinary stop watch. Turning time (t_2), which the time needed for machine to turn in order to harvest another stroke was considered and recorded as turning time loss. This time loss was taken as an indicator for the maneuver ability of the machine.

3.3. Field efficiency:

Field efficiency gives an indication of the time lost in the field and the failure to utilize the full working width of the machine. It was calculated as follows from the tested data ***(Kepner et al., 1982):***

$$\eta_f = \frac{Efc}{Tfc} \times 100,\ \% \quad \text{--- 4}$$

Where:

η_f = Field efficiency, %;

Efc = Effective field capacity, fed./h and

Tfc = Theoretical field capacity, fed./h.

4. Determination of fuel consumption rate:

The fuel consumption was experimentally determined by using a fuel consumption apparatus.

5. Cost analysis:

The cost of machine work was calculated by accumulating the fixed and variable costs**.**

A- Fixed costs:

1- Depreciation of the machine:

The depreciation of the machine was calculated from the following equation (straight-line method):

D = (P-S) / L --5

Where:

D = Machine depreciation, L.E/Year;

P = Purchase price, L.E;

S = Salvage or selling price, L.E and

L = Time between buying and selling, Year.

(Hunt, 1983)

2- Interest rate:

Interest rate was considered as a percentage of the machine purchase price per the year and in Egypt it was considered 9%.

3- Taxes, insurance and shelter:

The costs of taxes, insurance and shelter were considered 5% of the machine purchase price per the year.

B- Variable costs:

1- Repair and maintenance:

Repair and maintenance costs were considered as a percentage of the machine purchase price, spread over life of the machine, according to ***(Kaul and Egbo,1985)***, was 50% for combine, self-propelled (the combine without control system) but it was considered 20% for the combine with control system.

2- Fuel consumption:

Fuel cost (L.E/h) = Fuel consumption rate (l/h) × Fuel price (L.E/l) -----6

3- Lubrication:

Lubrication cost was taken as (15%) of fuel cost.

4- Labour:

Labourer wage was considered 25 L.E/ day work. The day work is 8 hours so that the labourer wage was 3.125 L.E/ h.

6. Criterion cost:

The criterion cost was estimated by using the following equation ***(Awady et al., 1982):***

Criterion cost (L.E/fed.) = Operating cost (L.E/fed.) + Grain losses cost (L.E/fed.)---7

Where:

$$\text{Operating cost} = \frac{\text{Machine cost, L.E/h}}{\text{Effective field capacity, fed./h}}, \text{L.E/fed.} \quad \text{------------------ } 8$$

We substitute of grain losses cost by straw losses cost.

<u>RESULTS AND DISCUSSION</u>

N.B.: The combine without control system can't work at cutting height (0.05 m) because of frequent breakdowns caused by a lot of obstacles which face it.

<u>1. Straw yield, Mg/fed.:</u>

Figure 3 shows the effect of combine forward speed, cutting height and combine system on the straw yield. It can be mentioned that increasing the combine forward speed tends to a slight decrease in the straw yield at all cutting heights and combine systems. The obtained values of straw yield were 4.378, 4.364, 4.348 and 4.319 Mg/fed. at the forward speeds of 0.8, 1.2, 1.8 and 2.5 km/h, respectively at cutting height of 0.05 m by

using the combine with control system. The other cutting heights had the same above mentioned trend for both combine systems. This trend may be due to the difficulty of keeping harvester adjusted at constant cutting height during high speed and the ability of plants to lodge at high forward speed.
On the other hand, increasing the cutting height from 0.05 to 0.20 m tends to decrease the straw yield from 4.319 to 3.599 Mg/fed. for the combine with control system and increasing the cutting height from 0.10 to 0.20 m tends to decrease the straw yield from 4.069 to 3.601 Mg/fed. for the combine without control systems at forward speed of 2.5 km/h. The other combine forward speeds had the same above mentioned trend for both combine systems.
The results also, indicated that the cutting height of 0.05 m gave the highest values of straw yield at all forward speeds by using the combine with control system.
The obtained values of straw yield were 4.103, 3.898 and 3.659 Mg/fed. for the combine with control system and 4.120, 3.902 and 3.662 Mg/fed. for the combine without control system at cutting heights of 0.10, 0.15 and 0.20 m, Respectively with forward speed of 0.8 km/h. The other forward speeds had the same above mentioned trend. It is remarked that, the straw yield decreases slightly by using the combine with control system compared with the combine without control system at cutting heights of 0.10, 0.15 and 0.20 m for all forward speeds. This may be due to increase cutting height while the combine header steps over the obstacles for the combine with control system.
Analysis of variance shows that the cutting height and combine system had a highly significant effect on the straw yield but the combine forward speed had no significant effect on the straw yield.
Generally, the highest value of the straw yield (4.378 Mg/fed.) was obtained at cutting height of 0.05 m and forward speed of 0.8 km/h by using the combine with control system. The straw yield decreased by increasing both the forward speed and cutting height for two combine systems.

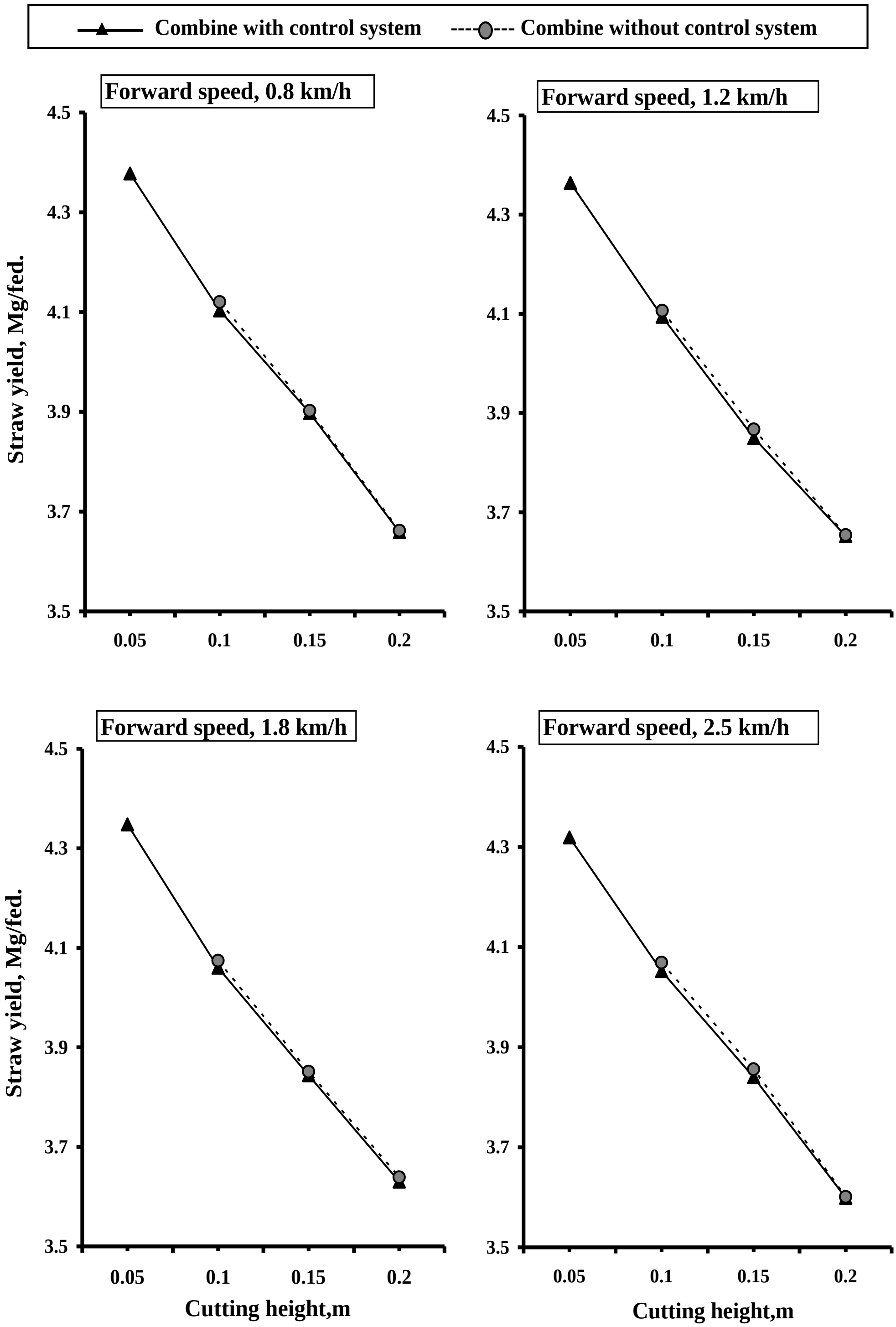

Figure 3: Effect of forward speed, cutting height and combine system on the straw yield.

2. Field efficiency,%:

Figure 4 illustrates the effect of combine forward speed, cutting height and combine system on the field efficiency. It can be notice that increasing the combine forward speed tends to decrease field efficiency with all cutting heights and combine systems. Meanwhile the increase of combine forward speed from 0.8 to 2.5 km/h leads to decrease the field efficiency from 84.96 to 62.35% at cutting height of 0.20 m by using the combine without control system. The other cutting heights and combine systems had the same above mention trend.

The cutting heights of 0.05, 0.10, 0.15, and 0.20 m gave the following values of field efficiency 83.00, 84.50, 86.50 and 89.50%, respectively at forward speed of 1.2 km/h by using the combine with control system. The same tendency was obtained at the other forward speeds and combine systems whereas, field efficiency increased by increasing the cutting height at all forward speeds and combine systems.

For all the combine forward speeds and cutting heights, the combine without control system gave the lowest values of field efficiency compared with the combine with control system. It is evident that the cutting heights of 0.10, 0.15 and 0.20 m gave the following values of field efficiency: 51.56, 55.64 and 62.35% for the combine without control system and 63.55, 64.51 and 65.71% for the combine with control system, respectively at forward speed of 2.5 km/h. The other forward speeds had the same above mentioned trend.

The analysis of variance indicates that the combine forward speed, cutting height and combine system had a highly significant effect on the field efficiency.

Generally, the field efficiency increased by decreasing the forward speed at all cutting heights and combine systems. But, increasing cutting height tends to increase the field efficiency at all forward speeds and combine systems. The combine with control system gave the maximum values of field efficiency compared with the combine without control system at all the other factors.

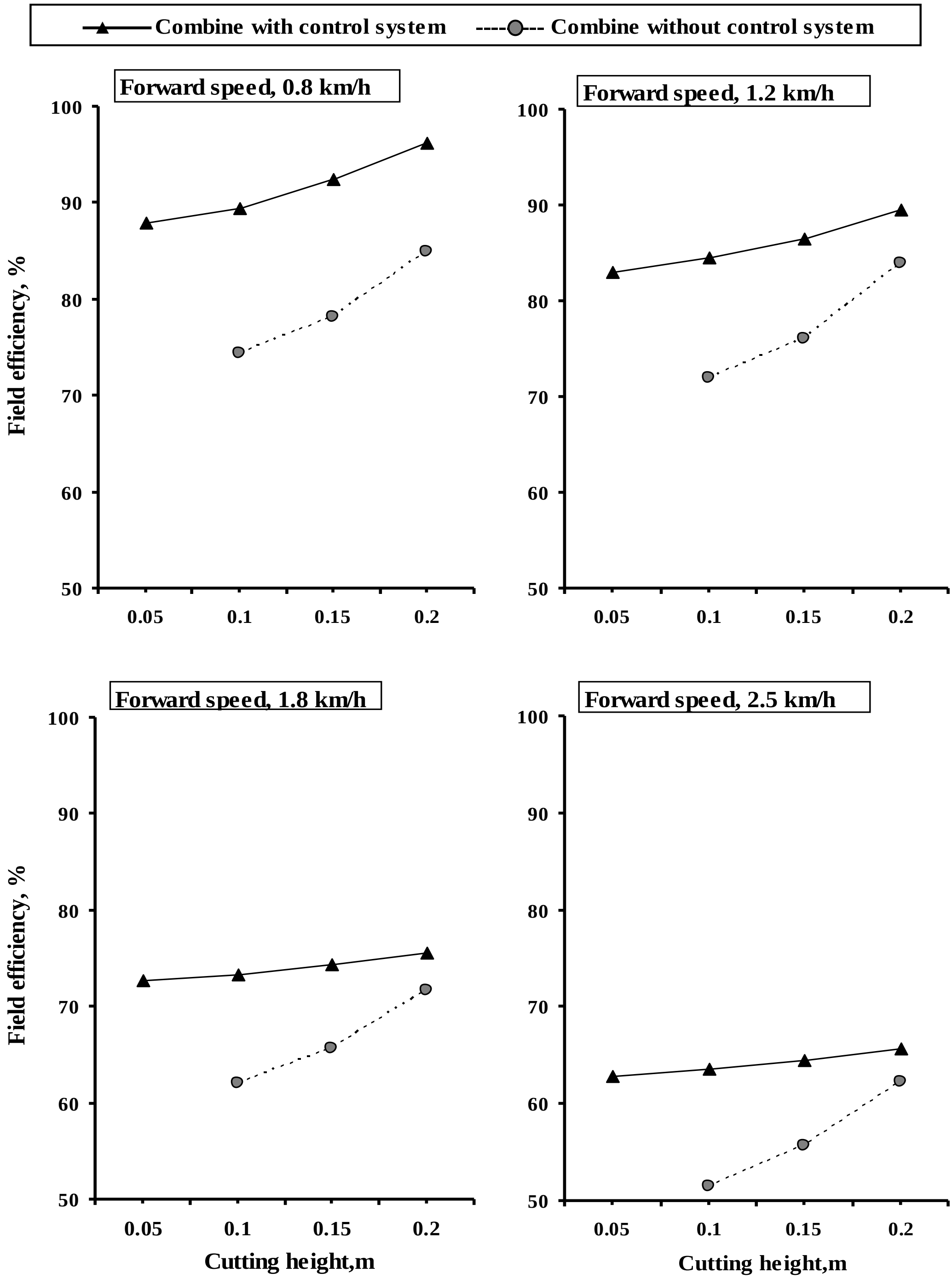

Figure 4: Effect of forward speed, cutting height and combine system on the field efficiency.

3. Criterion cost, L.E/fed.:

Figure 5 shows the effect of combine forward speed, cutting height and combine system on the criterion cost. It is evident that the increase of combine forward speed from 0.8 to 2.5 km/h tends to decrease the criterion cost from 298.346 to 183.033 L.E/fed. at cutting height of 0.15 m by using the combine with control system. The same tendency was obtained at the other cutting heights and combine systems whereas, criterion cost decreased by increasing the forward speed at all cutting heights and combine systems.

Results also, indicated that increasing the cutting height tends to increase the criterion cost for all forward speeds and combine systems. The cutting heights of 0.10, 0.15 and 0.20 m gave the following values of criterion cost 260.615, 273.662 and 276.356 L.E/fed., respectively at combine forward speed of 1.2 km/h by using the combine without control system. The other forward speeds and combine systems had the same above mentioned trend.

It was observed that, the maximum values of criterion cost were obtained with the combine without control system compared with the combine with control system at all forward speeds and cutting heights. The obtained values of criterion cost were 196.216, 207.394 and 219.112 L.E/fed. for the combine without control system and 163.374, 183.033 and 205.272 L.E/fed. for the combine with control system at cutting heights of 0.10, 0.15 and 0.20 m, respectively. The other forward speeds had the same above mentioned trend.

The lowest value of criterion cost (the optimum operating conditions) was (137.860 L.E/fed.) obtained with the combine with control system at forward speed of 2.5 km/h and cutting height of 0.05 m. However, the highest value of criterion cost was (361.588 L.E/fed.) obtained with the combine without control system at forward speed of 0.8 km/h and cutting height of 0.20 m.

The analysis of variance illustrates that the combine forward speed, cutting height and combine system had a highly significant effect on the criterion cost.

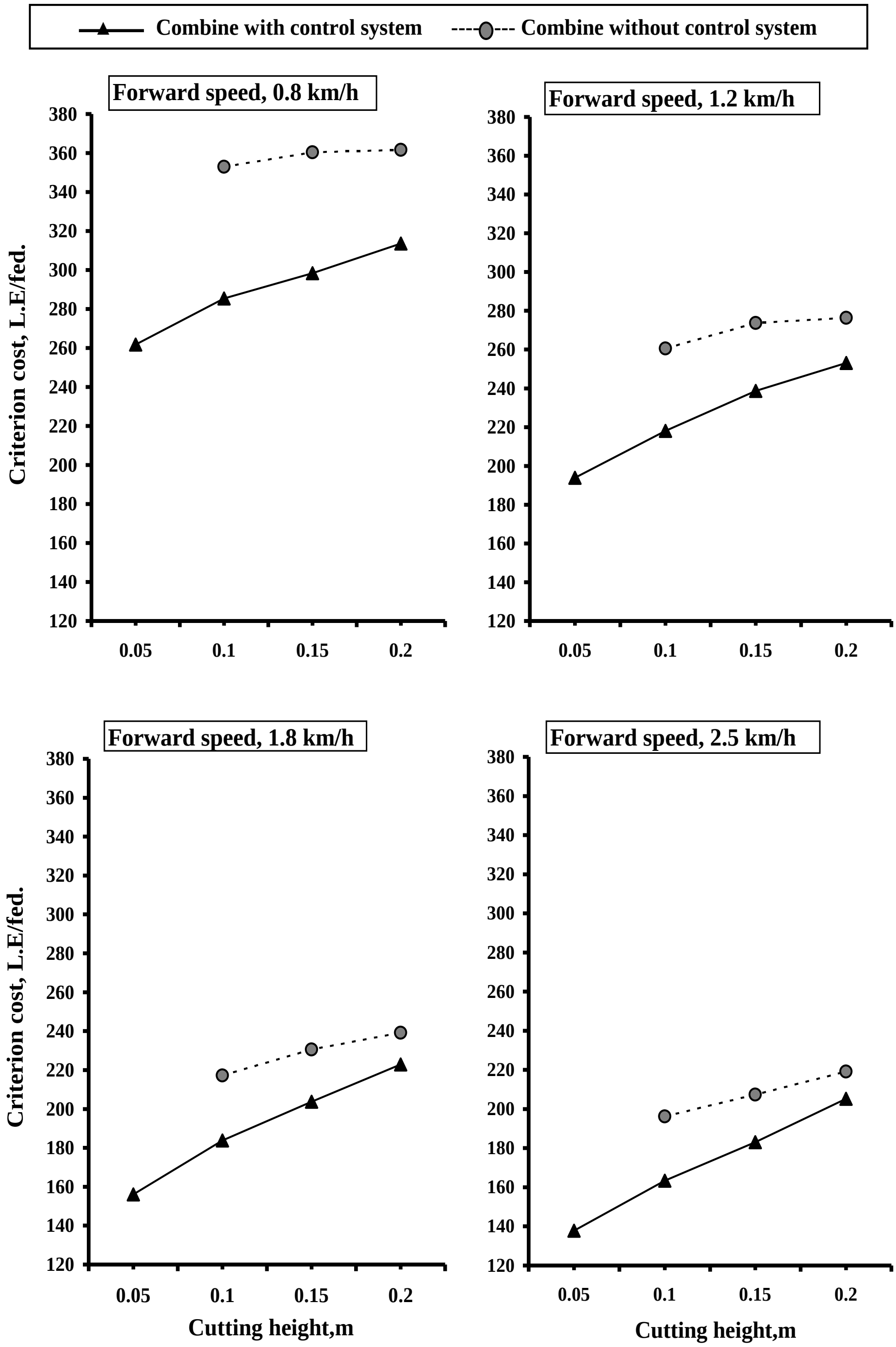

Figure 5: Effect of forward speed, cutting height and combine system on the criterion cost.

Generally, the criterion cost decreased by increasing the forward speed at all cutting heights and combine systems. But, it was increased by increasing the cutting height at all forward speeds and combine systems. On the other hand, the minimum values of criterion cost were obtained with the combine with control system compared with the combine without control systems at all the other factors.

CONCLUSION

The study aimed to the possibility of cutting the crop at the lowest possible level by manufacturing an automatic control unit which controls upping/downing the combine header, in order to avoid the obstacles which face it when lowering the cutter bar level.

The experiments were carried out during rice harvest season of 2007 in order to compare two combine systems for the combine (Yanmar-CA65V) under the same different operating conditions. The first combine has an automatic control unit (combine with control system). But the second combine hasn't an automatic control unit (combine without control system or the conventional combine). All experiments performed at the research farm of Rice Mechanization Center.

The final results indicated that the combine with control system is strongly recommended since it gives lower loss and costs, and higher field efficiency compared to the conventional combine.

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الملخص العربي

التحكم في صدر آلة الحصاد الجامعة

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يهدف البحث إلى إمكانية قطع المحصول على أقل ارتفاع ممكن وذلك من خلال تصنيع وحدة تحكم آلي تتحكم في رفع وخفض صدر آلة الحصاد الجامعة لمفاداة العوائق التي تواجهه عند خفض منسوب سكينة القطع. وتم تصميم وتصنيع وحدة للتحكم الإليكتروني في الصدر.

الأجزاء الأساسية لوحدة التحكم الآلي في رفع وخفض صدر آلة الحصاد الجامعة:

١- ثلاثة حساسات لرفع الصدر.

٢- حساس التحكم في ضبط ارتفاع الصدر.

٣- رَّبوط (إنسان آلي) التحكم في رفع وخفض الصدر.

٤- دائرة الإمداد بالقدرة.

٥- دائرة التحكم اليدوي في ارتفاع القطع.

٦- دائرة التحكم في رفع وخفض الصدر.

٧- دائرة التحكم في الرَّبوط (الإنسان الآلي).

وقد أجريت التجارب الحقلية لقياس مدى تأثير وحدة التحكم الآلي على آلة الحصاد الجامعة وذلك من خلال المقارنة بين آلة الحصاد الجامعة ذات نظام التحكم (الآلة مضاف إليها وحدة التحكم الآلي) وآلة الحصاد الجامعة بدون نظام التحكم (الآلة التقليدية) تحت ظروف التشغيل المختلفة وذلك في المزرعة البحثية لمركز ميكنة الأرز بميت الديبة – كفرالشيخ في موسم حصاد محصول الأرز (سخا-١٠١) لعام ٢٠٠٧م على مساحة فدانين ونصف تقريبا.

<u>وفيما يختص بظروف التشغيل تم دراسة العوامل الآتية:</u>

١- السرعة الأمامية لآلة الحصاد الجامعة (٠,٨ ، ١,٢ ، ١,٨ ، ٢,٥ كم/ساعة).

٢- ارتفاع قطع المحصول (٠,٠٥ ، ٠,١٠ ، ٠,١٥ ، ٠,٢٠ م).

٣- نظام آلة الحصاد الجامعة (آلة الحصاد الجامعة ذات نظام التحكم وآلة الحصاد الجامعة بدون نظام التحكم).

<u>تم دراسة تأثير كل من العوامل السابقة على المؤشرات الآتية:</u>

١- إنتاجية قش الأرز (ميجاجرام/فدان).

٢- الكفاءة الحقلية (%).

٣- التكاليف المعيارية (جنيه/فدان).

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[١] أستاذ ورئيس قسم الهندسة الزراعية – كلية الزراعة – جامعة كفر الشيخ.

[٢] باحث أول والمشرف على المكتب الفني – معهد بحوث الهندسة الزراعية.

[٣] مهندس – معهد بحوث الهندسة الزراعية.

ويمكن تلخيص النتائج المتحصل عليها تحت النقاط التالية:

1) أنسب ظروف تشغيل لآلة الحصاد الجامعة ذات نظام التحكم تم الوصول إليها عند سرعة أمامية ٢,٥ كم/ساعة وارتفاع قطع ٠,٠٥م.
2) أنسب ظروف تشغيل لآلة الحصاد الجامعة التقليدية تم الوصول إليها عند سرعة أمامية ٢,٥ كم/ساعة وارتفاع قطع ٠,١٠ م.
3) يفضل استخدام آلة الحصاد الجامعة ذات نظام التحكم الآلي حيث أنها أعطت أقل فاقد وتكاليف وأعلى كفاءة حقلية مقارنة بآلة الحصاد الجامعة التقليدية.