# MODIFICATION OF A REAPER-BINDER

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## ABSTRACT

*This study was carried out at a private farm in Owlad Sakr District, El-Sharkia governorate Egypt during 2016 summer season. Wheat Misr 1 variety was harvested using a modified self-propelled reaper-binder. The modification was assembling a conveyor mat to facilitate the harvested material failling down upon the soil surface. The experiment was established and designed statistically as a factorial experiment with three replications. the tested treatments were mat linear speed (0.09, 0.10, 0.11 and 0.12 m/s) and mat oblique angle (10, 20, 30 and 40$^{\circ}$ with the horizontal).. The results indicated that 0.09 m/s mat linear speed accompanied with 10$^{\circ}$ mat oblique angle accomplished higher machinery productivity of 3.55 Mg grains/h and 3.61 Mg straw/h,lower specific energy requirements of 26.43 MJ/Mg, lower conveying losses of 5% grains and 4.8% straw and lower operational costs of 891 LE/mg. So, it is recommended to apply the modified reaper-binder to harvest and bind for wheat and other grain crops.*

## INTRODUCTION

In Egypt, wheat is considered as a strategic and cashed crop. It is the staple diet of the people; it occupies a central position on agricultural policy. The Egyptian annual wheat cultivated area is about 3.147 million fed, which produced 8.520 million ton grains approximately with an average of about 2.707 ton grains/fed **(Hanan, 2014)**.

Despite of improved wheat varieties, effective chemical and hydrological inputs, Egypt produces less than 55% of its needs and imports the rest due to some factors. One important of these factors is wheat grain losses during harvest and post-harvest operations which represented about 14.46% of the total grain yield **(Hanan, 2014)**.

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In Egypt, at small holdings area, wheat is harvested manually using a sickle that breaks down plant stems, resulting in fallen ear heads, loss of panicles and grain shattering on the soil surface. Then, wheat plants remained on soil surface until reaching the proper moisture content for threshing, leading to grain losses due to birds, rodents and weather conditions. Then, wheat plants are manually bundled together and transported using animal drawn wooden carts or tractor drawn trailer outside the field to open threshing yards, losing a significant portion of grains i.e. 3.67, 3.98 and 0.24% of the total grain yield during harvest, bundling and transporting, respectively **(Abo El-Naga et al., 2009 and Muhammad et al., 2015)**.

In Egypt, there are about 3161 combine harvesters **(FAO, 2014)** which were widely operated for full rice harvest and threshing. While, the combine harvester causes more wheat straw losses. So, farmers tend to apply the partial mechanization in wheat harvest to keep the wheat straw without loss. Using self-propelled mower or reaper minimized the harvest grain losses to be 2.35% **(Abdrabo, 2015 and Murumkar et al., 2014)**. Also, using the binder device minimizes the bundling losses to be 0.86% **(Pawar et al., 2008; Abo El-Naga et al., 2009 and Muhammad et al., 2015)**.

**El-beba et al., (2015)** used the combine harvester after removing threshing and winnowing parts and heightened the pick-up shaft to 0.20 m above the original position with fixing a metal mat for transporting wheat plants to fall down upon the soil surface. This procedure resulted in a significant grain shattering. Whilst, some Egyptian techniques attached a binder device with the combine harvester to operate as a self-propelled reaper-binder. Then, a considerable portion of crop yield losses is occurred due to loosening some bundle ties. Also, more time is required to retie them.

This study aimed to modify the combine harvester which is operated as a self-propelled reaper-binder to minimize wheat crop yield losses and offer more useful operational time.

## MATERIAL AND METHODS

### Experimental procedures:

To fulfill the study objective, a field experiment of 70 x 60 m area was carried out at a private farm in Owlad Sakr District, Sharkia governorate

Egypt during 2016 summer season. A modified self-propelled reaper-binder was used to harvest wheat Misr 1 variety of 1.06 m plant length, 400 plants/$m^2$, 9.00% wheat straw moisture content (w.b.) and 15% grain moisture content (w.b.).

After its recommended salvage life, a self-propelled combine harvester was operated as a reaper-binder by removing threshing, winnowing and cleaning devices. Table (1) indicated the specifications of the used combine harvester. A binder device was attached with the machine. The binding speed was 0.23 m/s and bundle mass was 1.33 kg. To conform with the binding speed, the reaper-binder operated at 1.5 km/h forward speed. It was achieved by selecting appropriate gears, adjusting machine engine throttle at the maximum position at adjusting the engine speed around 85%. The used self-propelled reaper-binder was modified by assembling a conveyor mat to facilitate the harvested material failing down upon the soil surface. The mat consists of the following components:

1. Frame: The frame is fabricated from U shape hollow galvanized steel with cross sectional area of 0.10 x 0.05 x 0.005 m. The frame consists of two trapezoidal shape sides of 1.85 m base, 0.60 m height and 0.90 m lateral spacing apart.

2. Conveyor mat: The harvested material is conveyed using a inclined mat of 1.25, 0.95 and 0.01 m in length, width and thickness, respectively. It is assembled with two drums of 0.075 m diameter and 0.85 m length. The upper drum height is 0.70 m from the soil surface. While, the lower drum is a movable to make the mat oblique angle is adjustable.

3. Corona shaft: A corona shaft is attached with the binder device. It transmits the motion from the binder device to a drive pulley of 0.10 m diameter, which is assigned with the corona shaft. Then, the motion is transmitted through a rubber conveyor belt of 0.65, 0.09 and 0.005 m in length, width and thickness, respectively to a driven pulley of 0.05 m which is assigned at the upper drum shaft, that transmits the motion to the conveyor mat. Figure (1) demonstrates the mat components and the harvested crop line direction.

Table (1): Specifications of the used combine harvester

| | |
|---|---|
| Source of Manufacture | Japan |
| Type | Self-propelled |
| Model | Kupota CA-385 EG |
| Dimensions, m (length × width × height) | 4.675 × 1.905 × 1.680 |
| Reaper working width, m | 1.60 |
| Source of power | Engine, Turbo diesel, 4 stroke, water cooled, 3 cylinder |
| Maximum power output, kW | 67.50 |
| Engine speed, rpm | 2700 |
| Mass , kg | 1100 |
| Traction device | Rubber tracks as diameter |
| Salevage life, hrs. | 10000 |

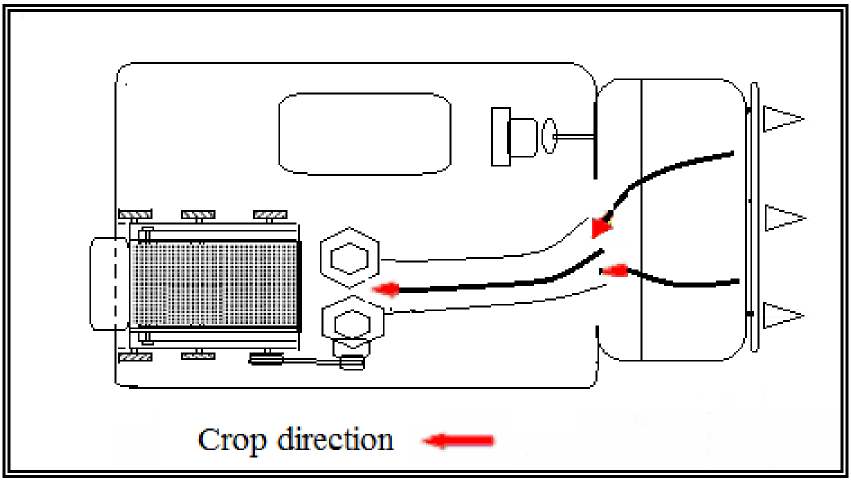


Fig. (1): Crop line direction at the modified reaper-binder.

**Treatments and statistical design:**

During the experiment the following treatments were tested:

1. Mat linear speed: It included levels of 0.09, 0.10, 0.11 and 0.12 m/s.
2. Mat oblique angle: It included levels of 10, 20, 30 and 40$^{\circ}$ with the horizontal.

The experiment was established and designed statistically as a factorial experiment in completely randomized blocks with three replications. The reaper-binder before modification was considered as the control treatment.

**Measurements:**

Machinery productivity (Pr):

It is estimated as cited by **Srivastava et al. (2006)** as follows:

$$Pr = \frac{1}{ATT} \text{, Mg/h} \qquad (1)$$

Where: *ATT* is the actual total time required for accomplishing a bundled mass of wheat plants (1.33 kg), hrs. Then, wheat grains and straw are calculated on basis of 14% moisture content (d.b.).

**Machinery specific energy requirements:**

***a. Specific reaping, conveying and binding power requirements:***

For each one of the reaper, conveyor mat and the binder, the expended torque is measured using torque transducer and data acquisition system. The expended power (*Pth*) is determined as follows:

$$Pth = torque \text{ (kN.m) x } angular\ velocity \text{ (rad\textbackslash s), kW} \qquad (2)$$

***b. Specific traction power requirements:***

As cited by **ASAE (2003)** and **Ismail (2007)**, the auxiliary tractor of 82.8 kW power pulls the used reaper-binder. The draught force is measured as the horizontal component of the force between the driving tractor and the reaper-binder using a spring dynamometer. The average dynamometer readings are determined when the auxiliary tractor and the reaper-binder are moving in sequence upon the experimental soil surface. The traction force required is estimated as the difference between the dynamometer reading and the pulling resistance of the 45 kW tractor which is estimated by pulling the tractor alone upon the experimental soil surface. Then, the power required (*P*) is calculated as follows:

$$P = TF \text{ x } S \text{, kW} \qquad (3)$$

Where: *TF* is traction force, kN.

*S* is actual tractor forward speed, m/s.

$$Power\ requirements = \sum Reaping,\ binding\ and\ conveying\ power \text{, kW} \qquad (4)$$

$$Specific\ machinery\ energy\ requirements = \frac{3.61\ power\ requirements}{Pr},\ MJ/Mg \quad (5)$$

Where: 3.61 is the coefficient of conversion from kW.h to MJ.

**Wheat crop conveying losses.**

Wheat crop conveying losses is determined according to **Shamabadi (2012)**:

$$\eta_f = \frac{AFC}{TFC} x\ 100 Wheat\ conveying\ losses = \frac{w_t - w_b}{w_t} x100\ ,\ \% \quad (6)$$

Where: $w_g$ is mass of conveyed plants, Mg/h.

$w_b$ is mass of bundled plants, ton/h.

**Machinery operational costs:**

As cited by **Begum et al., (2012)**, the operational costs are calculated on the basis of fixed costs and variable costs, whereas fixed costs include depreciation, interest, shelter and taxes costs. Depreciation costs are determined by straight line method, described by Zami et al. (2014). Variable costs include fuel, lubrication, repairs and maintenance and operator costs. In this study, 3.5% of purchase price is considered as repair costs for every 100 h of effective operation. The machine salvage value is considered as 10% of purchase value.

$$Threshing\ criterion\ costs = \frac{operational\ costs\ (LE/h)}{Pr} + lossed\ grains\ and\ straw\ price\ ,\ LE/Mg \quad (7)$$

**Statistical Analysis:**

Data of the coefficient of variation for wheat conveying losses are analyzed statistically to determine the standard deviation. SPSS (Version 20.0) computer software package is used to employ the analysis of variance test and the LSD tests for wheat conveying losses data.

**Regression and Correlation Analysis:**

Microsoft Excel 2016 computer software is used to employ the simple regression and correlation analysis to represent the relation between wheat conveying losses and both mat linear speed and mat oblique angle.

## RESULTS AND DISCUSSION

**Machinery Productivity:**

Figure (2) exhibits that the modified machine accomplished more wheat crop yield per unit time (about 13%) than the machine before modification.

It is shown that there is an inversely proportion of machinery productivity with both mat linear speed and mat oblique angle. The higher machinery productivity values of 3.55 Mg grains/h and 3.61 Mg straw/h were obtained at 0.09 m/s mat speed accompanied with 10° mat oblique angle. It may explained that at the higher mat speed levels, the bundles congestion may lead to the increased impact action between bundles and soil surface. Whilst, at the higher mat oblique angle levels, the height of bundles falling down is higher, resulting more impact force between bundles and soil surface. The higher impact force between the bundles and the soil surface may result in loosening the bundle binds. Consequently, more wheat plants may be lost.

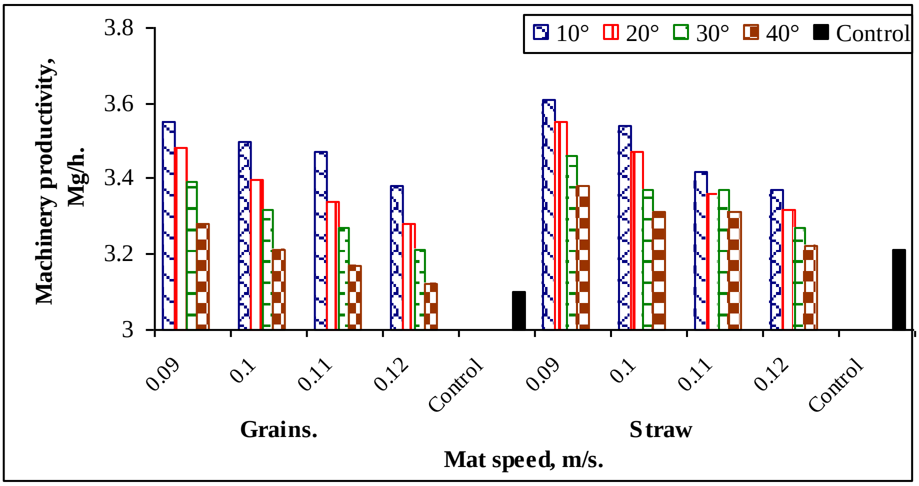

Fig. (2): Effect of mat speed and mat oblique angle on machinery productivity.

**Machinery Specific Energy Requirements:**

As indicated in figure (3), the modified machine required more energy (about 10-30%) than that required before modification. The lower specific energy requirements value of 26.43 MJ/Mg was achieved at 0.09 m/s mat speed accompanied with 10° mat oblique angle. The machinery specific energy requirements are proportional with both mat speed and mat oblique angle. It is due to the higher friction force between the conveyed bundles and the mat surface.

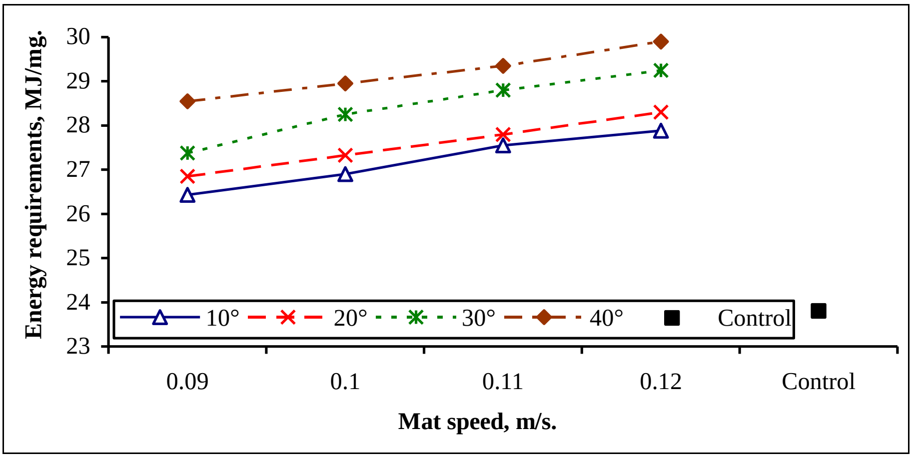


Fig. (3): Effect of mat speed and mat oblique angle on machinery specific energy requirements.

**Wheat Crop Conveying Losses:**

As shown in figure (4), machine modification saved more grains and straw (about 58%) from losing, comparing with the machine without modification. The figure indicates that the lower wheat conveying losses values of 5% grains and 4.8% straw were obtained at 0.09 m/s mat speed accompanied with 10° mat oblique angle. This result may attributed to the increased shaking action that accompanied with the higher values of mat speed, causing grain separating from wheat spikes. Meanwhile, as the the proportion of mat oblique angle with the bundle falling down height increases the impact action between bundles and the soil surface, leading to more bundles binds loosening.

The statistical analysis shows that the lower standard deviation value of ± 0.352 for the coefficient of variation for wheat conveying losses was achieved with 0.09 m/s mat speed accompanied with 10° mat oblique angle. The analysis of variance test indicated that there is a significant difference in wheat conveying losses due to mat speed and mat oblique angle treatments. LSD test at 0.05 level shows that 0.09 m/s mat speed accompanied with 10° mat oblique angle achieved lower values of wheat conveying losses among the other treatments.

The regression and correlation analysis revealed that there is a significant highly positive correlation between wheat conveying losses (y) and mat linear speed (x) at different levels of mat oblique angle as follows:

Grains:

$10^{\circ}$: y = 0.0367 x + 5.2792 292 $R^2 = 0.9492$

$20^{\circ}$: y = 0.0833 x + 5.6833 $R^2 = 0.9353$

$30^{\circ}$: y = 0.0400 x + 6.3125 5 $R^2 = 0.9493$

$40^{\circ}$: y = 0.0433 x + 7.3417 $R^2 = 0.9374$

Straw:

$10^{\circ}$: y = 0.0160 x + 4.1752 292 $R^2 = 0.9112$

$20^{\circ}$: y = 0.0430 x + 5.3813 $R^2 = 0.9313$

$30^{\circ}$: y = 0.0100 x + 6.0115 5 $R^2 = 0.9143$

$40^{\circ}$: y = 0.0133 x + 6.5417 $R^2 = 0.9341$

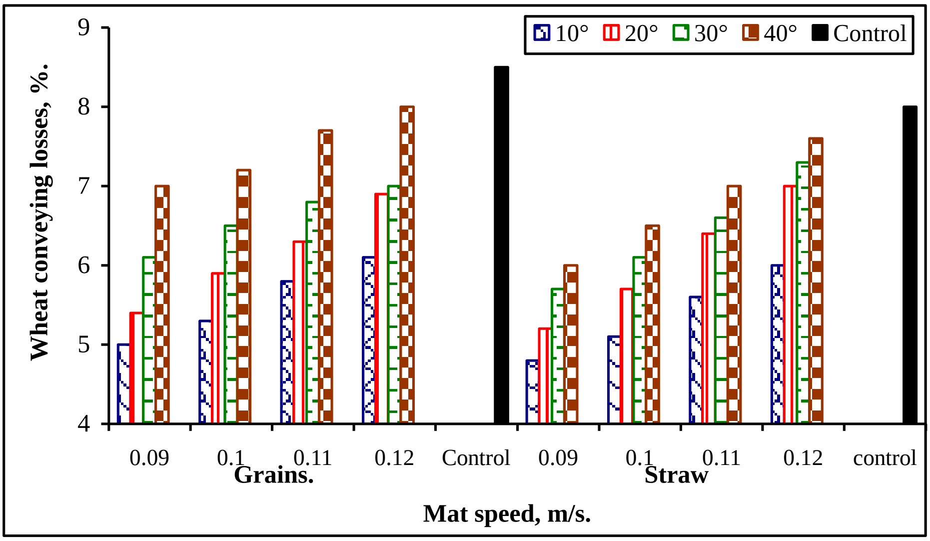


Fig. (4): Effect of mat speed and mat oblique angle on wheat crom conveying losses.

**Machinery Operational Costs:**

Figure (5) displays that operating the modified machine at 0.09 m/s mat speed accompanied with $10^{\circ}$ mat oblique angle achieved the lower operational costs value of 891 LE/fed. The modified machine safed about 14% of operational costs before modification. This result may returned to the machine modification, which offers the increased field capacity accompanied with the lower conveying losses.

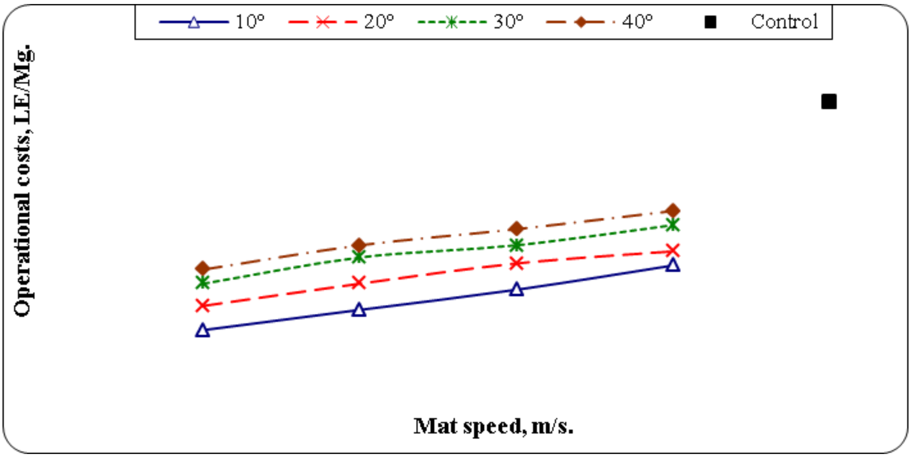


Fig. (5): Effect of mat speed and mat oblique angle on machinery operational costs.

## CONCOLUSION

The obtained results of this study could be concluded as follows:

1. The modification of the used reaper-binder accomplished more machinery productivity by 13%.
2. The modification expended more specific energy requirements by 10%.
3. The modification saved 58% of grains and straw from losing.
4. The modification decreased the machinery operational costs by 14%.

Finally, it is recommended to apply the modified reaper-binder for wheat and other grain crops.

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## الملخص العربي

# تعديل آلة الحصاد والتربيط

**أسامة طه بهنس* و شرين فؤاد عبد الحميد** و هبة عبد المحسن لطفي*****

أجريت هذه الدراسة بمزرعة خاصة بمركز أولاد صقر بمحافظة الشرقية خلال الموسم الصيفي ٢٠١٦، وقد تم حصاد محصول القمح صنف مصر ١ باستخدام آلة معدلة للحصاد والتربيط وذلك بتركيب حصيرة ناقلة لتسهيل سقوط حزم المحصول على سطح الأرض بهدف تقليل فواقد المحصول. وقد تم تصميم وتنفيذ التجربة إحصائياً كتجربة عاملية (قطاعات كاملة العشوائية) في ثلاث مكررات، وتضمنت معاملات الدراسة السرعة الخطية للحصيرة الناقلة (٠.٠٩ و٠.١٠ و٠.١١ و٠.١٢ م/ث) وزاوية ميل الحصيرة الناقلة على الأفقي (١٠ و٢٠ و٣٠ و٤٠°). وأشارت نتائج الدراسة إلى أن تشغيل الآلة مع السرعة الخطية للحصيرة الناقلة ٠.٠٩ م/ث وزاوية ميل الحصيرة على الأفقي ١٠° يحقق أعلى قيمة لإنتاجية الآلة بمقدار ٣.٥٥ طن حبوب/ساعة و٣.٦١ طن قش/ساعة وأقل قيمة لمتطلبات الطاقة النوعية بمقدار ٢٦.٤٣ ميجا جول/طن وأقل قيمة لفواقد المحصول. أثناء النقل بالحصيرة بمقدار ٥% للحبوب و٤.٨% للقش وأقل قيمة لتكاليف تشغيل الآلة بمقدار ٨٩١ جنيه/فدان. س

ولذا فإنه يوصى باستخدام آلة الحصاد والتربيط المعدلة لحصاد القمح ومحاصيل الحبوب الأخرى.

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