FIELD EVALUATION OF THE EQUIPMENT AVAILABLE FOR RICE STRAW BALING

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ABSTRACT

Reduction of environmental pollution is an important task for the Egyptian government. The burning of rice straw is one of the main sources of seasonal air pollution that known as black cloud. Rice straw may be used for several economical applications such as animal feed, animal house bedding, constructions etc. The loose nature of rice straw makes it difficult to handle rice straw from the field to the locations in which it is required. The availability of baling machines may attract the farmers to collect and sell rice straw bales instead of burning in the field. Several governmental organizations have been assigned to make the technology of rice straw collection and baling available for the farmers to control the phenomena of burning rice straw in the fields. Consequently, variable types of the locally fabricated as well as imported balers are available. The current research aimed to evaluate the performance of the most famous types of available balers in baling the mechanically harvested rice straw. The evaluated machines were; a) the locally fabricated tractor drawn and stationary rectangular balers, b) the imported tractor drown and stationary rectangular balers and, c) the imported cylindrical baler. The machines were evaluated for baling rate, straw losses (unpicked straw), bale density, loose bales, field capacity and efficiency.

The results show that pickup rate ranged from 42 to 62 kg/min for all the tested balers. Stationery rectangular balers deliver up to 151 bale/h compared to 112 bale/h for the tractor pulled balers. Bale density for all the rectangular balers ranged from 131 to 146 kg/m^3. The performance of the locally made rectangular balers was very close to that of the imported balers either tractor drawn or stationary machines. Therefore, the locally made types of balers may compete in the local market and for export. The cylindrical baler forms stronger bales of larger size and higher density.

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INTRODUCTION

According to El-Gindy (2009), the burning of crop residues is one of national problems in Egypt especially after harvesting or threshing operations to the different crops. The main objective in the present study is: Design, fabricate and evaluate the mechanical system of threshing and handling rice straw directly to the baler. A conveyor belt was designed to transport the rice straw from threshing machine to the baler. Selections of all bearings of the mechanical system were done according to the load carrying capacity. ending joints were checked against the stresses. According to Afifi et al (2002), in Egypt, there are about 1.5 million feddan cultivated area with rice each year. This resulted in nearly 4 million tons of rice straw. Most the farmers used to burn their straw yield at the end of the rice-harvesting season. This may have been considered as the reason for the phenomena known as black cloud that shrouds Cairo at the month of October every year. Field baling is essentially packing operation performed for hay and crop residues to facility handling, transporting, easy transport, processing and storing. Baling may be necessary for handling rice straw from the fields to the locations in which its economical utilization takes place. According to Nader (2010) some of the uses of rice straw are; dairy feeding, beef feeding, erosion control, livestock bedding, building construction and mushroom bedding. Results of environmental studies (California Agriculture Magazine, 1991) indicated that one tone of rice straw burning would produce about 56 kg of carbon monoxide (CO). Therefore, if only one million tones have been burnt each year, the total amount of carbon monoxide (CO) would have reached to 56,000 tones. This indeed, will cause increased the rate of air pollution that considers the primary reason of infection by cancer disease. Therefore, overcoming the rice straw problem has stimulated scientists and the Egyptian Government in finding alternative handling methods to protect the environment by preventing air pollution and health hazards. Baling the rice straw into rectangular or round bales is the important step in handling rice straw for other applications such as animal feeding, fuel, and fiber for paper manufacturing. Wang et al (2011) For resolving harvesting technology of fresh rice straw silage and plugging of the round steel-roll baler in China, experimental researches were carried out. For harvesting technology, baling silage and chopping silage were experimented. For the round baler, three kinds of feeding rolls equipped for enhancing feeding capability were experimented separately by reliability. Experimental results indicate: harvesting technology of baling fresh rice straw as silage is practicable; slicing-disc feeding rolls can be used to the baler to resolve plugging in straw-baling course. And through further experiments by reliability and density, optimal structure of the feeding roll is obtained: big and small slicing-discs arranged in interval and inclination, distance between slicing-discs being 30–40 mm.

Abdel-Mottalb(1997) designed a new system to remove the field residuals by cutting, collecting, chopping and baling in one operation. It was designed by combining the vertical flail mower and the pick-up baler by modifying the designs necessary for hitching power transmission, He concluded that the unit area decreased with the increase of forward speed. Embaby (1985) under taken a field study to evaluate harvesting and baling operation of wheat in desert lands. The baling operation of wheat straw using pick-up baler was a function of baling rate (132.5) bales per hour with 0.118m3/bale, (bale density 90kg/m3, machine efficiency 86%) and the machine operator experience. El-Danasory and Imbabi (1999), studied the mechanical pick-up for packing of wheat straw after harvesting with combine. Results indicated that baler capacity was affected by weight of straw yield and forward speed. Baler losses decreased by decreasing forward speed and decreasing period after harvesting. They also stated that the of using balers to pickup baling straw was less than the half cost of manual method. Mosa (1994) constructed and tested a straw cutting and compressing device (baler) integrated with a combine. He concluded that rough straw present discharged from the chopper decreased by decreasing straw moisture content, increasing chopper r.p.m, and decreasing clearance, lower feed rates also resulted in lower rough straw percent. He also added that bales are more stable and less dense when they have a high percentage of rough straw. Straw length has significant influence on bale density. Shorter straw results in higher density bales.

MATERIALS AND METHODS

The locally made balers as well as the commercially available imported balers were compared. The balers were technically field evaluated for baling rice straw as one of the most crop residue that urgently requires baling. The conditions of the test field may be presented in Table (1):

Table (1) Conditions of the experimental field

Item	Information
Crop residual to be baled	Rice straw
Straw density, kg/m^2	0.6
Residues quantity ton/fed	2500
Type of Harvesting machine	General purpose combine
Combine header width	3 m
Dimension of windrow	1.0 -1.2 m width × 40-60 cm height
Straw weight, kg/m of windrow	1.8

The study included variable machines that represent the all commercial baler types that are in use for crop residues baling operation. The machines included in the study may be classified as follow:

- Local made tractor trailed pick up baler
- Local made stationery baler
- Imported tractor trailer baler
- Imported stationery baler
- Imported round baler

The most important data of the balers may be presented in Table (2)

Table (2) Data of the tested balers

Tem	Locally made t. pulled	Local made stationery	Imported t. pulled	Imported stationery	Imported round
Bale shape	rectangular	rectangular	rectangular	rectangular	round
Piston dimension	30×40	30×40	30×40	30×40	120×125
Baler dimension	6.0 × 2.5× 1.6	4.9 × 2.5× 1.6	4.97 × 2.5× 1.76	4.14 × 2.45× 1.72	4.43 × 2.36× 2.21
Weight, kg	1420	1510	1200	1535	1800
Pick-up width, cm	146	150	130	140	167
Type of feeding	Pick-up	feeding	Pick-up	feeding	Pick-up
Press mean	Mechanical	Mechanical	Mechanical	Mechanical	Hydraulic

The performance parameters considered in the current study were;

a- Baler pick up rate that computed as follow:

$$Baler\ pick\ up\ rate = \frac{(W_1 - W_2) \times S}{1000} \qquad (ton/h)$$

Where;

W1 = weight of straw in 1 m of the windrow (kg/m)
W2 = weight of unpicked straw of the windrow (kg/m)

b- Baler baling rate that is the number of bales delivered from the baler per one hour.

c- Straw losses (unpicked straw): weight of straw left from the windrow after the pass of baler.

d- Bale density;

$$Bale\ density = \frac{Bale\ \ weight\ (kg)}{Bale\ \ volume\ (m^3)} \qquad (kg/m^3)$$

e- Percent of loose bales;

$$Percent of\ \ loose\ bales = \frac{Number of\ \ loose\ bales/operation\ \ day}{Total\ bales\ produced\ \ in\ \ the\ \ operation\ \ day} \times 100$$

Field capacity and efficiency considering the time losses that related to operation and that related to breakdowns and repair in the field.

RESULTS AND DISCUSSION

Table (3) presents the performance of the tested balers. Weight of the rectangular bales of the tractor pulled and stationary balers ranged from 19 to 21 kg. The round bale weight of the tractor mounted round baler was 120 kg. Advancing speed of the tractor mounted rectangular baler ranged from 0.46 to 0.52 m. Advancing speed of the baler that form round bale was about 0.55 m/s. Dimensions of the rectangular bale of the tractor mounted as well as stationery balers was 0.36 ×0.4×1 m. The dimensions of the round bale of the round baler was 1.3 m diameter and 1.2 m length.

Table (3) performance of tested balers

Item	Locally Fabricated		Imported		
			Rectangle		Round
	Kader	Helwan stationery	Trailed	Stationary	Italy
Moisture content of straw, %	12 %	13%	14%	14%	14%
Average baler advancing speed, m/s	0.46	--	0.52	--	0.55
Baler pick up rate, ton/h	2.55	3.8	3.25	4.1	3.1
Baler pick up rate, Kg/min	42	61	48	62	52
Unpicked material, Kg/m² of the windrow	0.27	--	0.25	--	0.22
Unpicked material, Kg/m² of the field	0.09	--	0.08	--	0.07
Straw losses %	15 %	--	14 %	--	12 %
Ball average weight, kg	19	21	20	21	120
Bale size (dimensions), m	0.4×0.36×1				D = 1.2 L = 1.2
Bale volume, m³	0.144	0.144	0.144	0.144	0.432
Bale density, kg/m³	131	146	138	146	278
Capacity bale / h	101	142	112	151	21
Field capacity Fedan/h	1.19	1.46	1.34	1.49	1.41
Efficiency, %	0.76 %	82%	78%	85 %	80 %
Loose bales, %	2.6	1.8 %	2.2 %	1.5%	1 %

The basic functions of the balers are to pick up the residual from the windrow and to form baled. Figure (1) shows the balers pick up rate and the rate of forming bales. As shown in the Figure, stationery balers handle and compress within higher rate. The locally made stationery baler handles 61 kg/min and the imported one handles 62 kg/min. Actually, the straw fed to the stationary balers by labors, so that the rate of feeding may depend on the labor. The tractor trailed balers handle less straw compared to the stationery balers. The locally made tractor trailed baler pick 42 kg/min and the imported one pick 48 kg/min. The moving (tractor trailed) round bale baler pick 52 kg/min. The pick-up rate may depends on several factors from which the size and density of the windrow is the most important.

The rate of baling by the different balers may depend on the pick-up rate as well as the size and density of the bale. The size of the rectangular bale is so much smaller than that of the round one. Actually, the volume of the rectangular bale is about 0.144 m^3 while that of the round one is

0.432 m^3. Actually there is also large difference in bale density. Tractor trailed balers that form rectangular bale deliver 133 bale/h and 144 bale/h for the locally made baler and the imported one respectively. The stationery balers deliver 174 and 177 bale/h for the locally made and the imported baler respectively. The round baler delivers only 26 bal/h because the size and the weight of the round bale is much larger. The percent of straw losses or unpicked straw was determined for the moving balers. As shown in Fig (2), straw losses were 15% for the locally made baler and14% for the imported rectangular baler. The straw losses left behind the tractor driven round baler determined to be 12%.

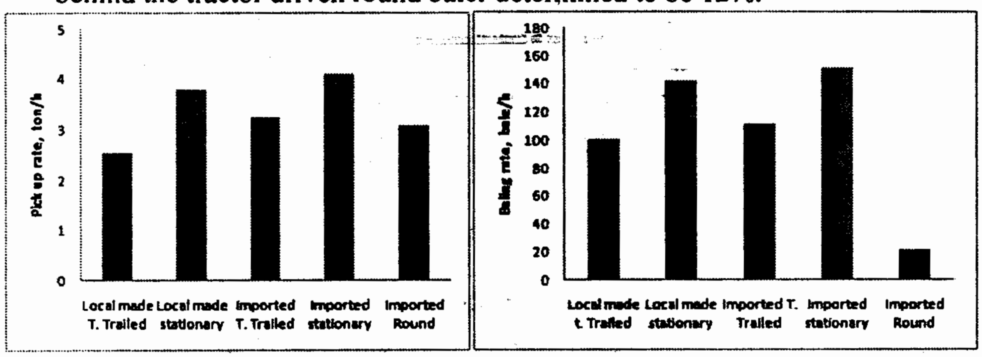

Fig (1) Pick-up rate and balling rate of the locally made VS imported balers

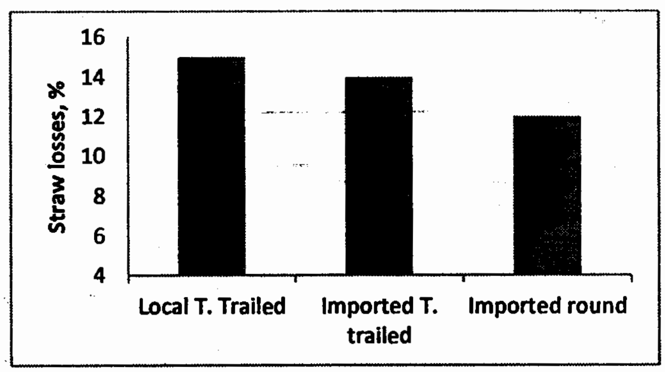

Fig (2) straw losses (unpicked straw) of the tractor pulled balers

Figure (3) show the bale density of the different tested balers. Bale density of the tractor driven rectangular balers is 131 and 138 kg/m^3 for the locally made and the imported balers respectively. The density of the rectangular bales of the stationary balers was 146 kg/m^3. The density of the round bale delivered by the moving round baler was as high as 278 kg/m^3.

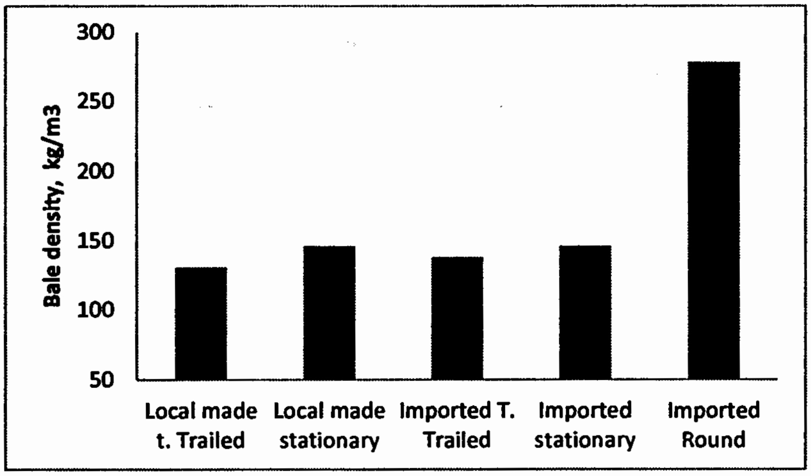

Fig (3) density of the bales delivered from different balers

The percent of loose bales as a result of continuous operation indicated in Fig (4). The Figure show that loosen bales ratio found behind the tractor pulled and driven balers determined to be over 2% either for the locally made or for the imported balers that deliver rectangular bale. The stationary balers deliver less percent of loose bales that estimated to be ranged from 1.5% to 2%. Actually the proper maintenance of the baler may reduce the above mentioned ratio of loosen balers. The round baler performs better where the loosen bales was up to 1% only. Poor maintenance of any type of the balers expected to largely increase loosen bales.

Figure (5) show the field capacity and efficiency of the different tested bales. The field capacity of the stationery balers was computed considering the production of straw is 2.5 ton in average with no pick-up losses and the capacity was then computed in Fed/h. According to the above mentioned assumption, the capacity of the stationery balers was 1.46 and 1.49 Fed/h for the locally made and the imported balers respectively. Field efficiency for the stationery balers was computed considering the time losses due to breakdowns only. Consequently, the field efficiency of the stationery balers was 82% and 85% respectively. Field efficiency of the moving balers was 76% for the local made rectangular baler, 78% for the imported rectangular baler and 80% for the round baler.

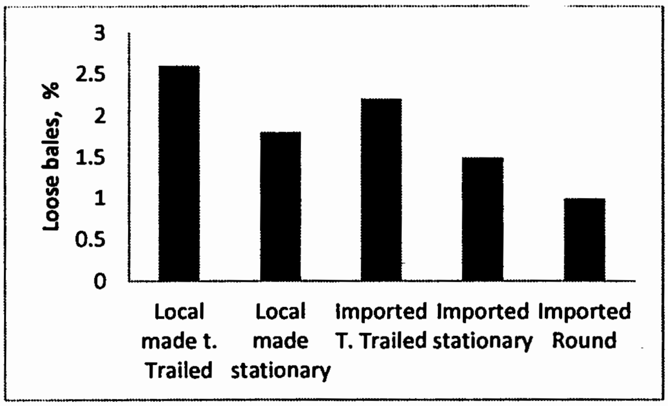

Fig (4) percent of loosen bales of the locally made VS imported balers

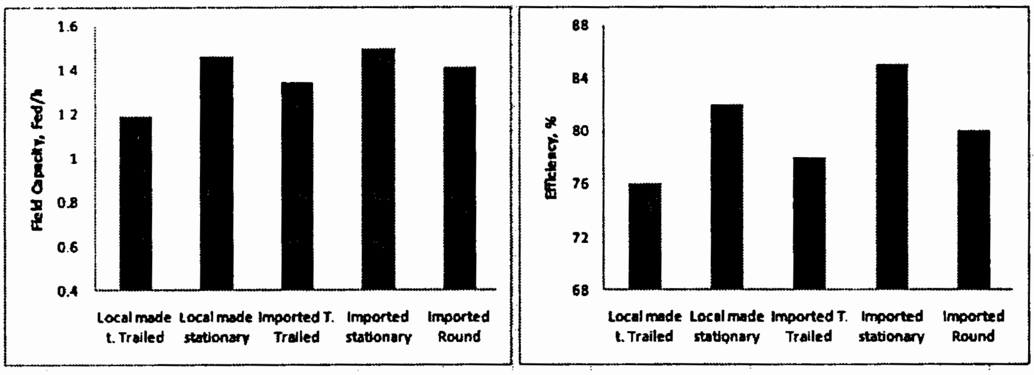

Fig (5) Field capacity and efficiency of locally made vs imported balers

CONCLUSION

The performance of the locally made and the imported balers was evaluated for pick-up rate, baling rate, bale density, loosen bales, field capacity and efficiency. The locally made rectangular baler pulled by the tractor performs very close to that imported one. The two balers deliver bales of similar size with the rate of 101 and 112 bales/h for the local and imported baler respectively. The field efficiency was 76% and 78% for the previously mentioned balers. The locally made stationery baler deliver 142 bale/h at efficiency of 82% and the imported one deliver 51 bales/h at the efficiency of 85%. Bale density of all the rectangular balers either tractor pulled or stationery deliver bales of density range 131 to 146 kg/m^3. The round bale form large bales of 120 kg/bale with field efficiency 80% and bale density 277 kg/m^3.

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الملخص العربى

التقييم الحقلى للمعدات المتاحه لكبس قش الأرز

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يزرع فى مصر حوالى ١,٥ مليون فدن بالأرز سنويا ويتخلف عنها ما يربو على ٤ طن من القش بعد الحصاد . وبالرغم من أن قش الأرز له إستخدامات عديده فهو يستخدم فى تصنيع الأعلاف الحيوانيه ويستخدم كفرشه للحيوانات فى الحظائر ولزراعة عيش الغراب ويدخل فى الإنشاءات والعزل إلا أنه يمثل عبئا على المزارع ونقله من الحقل إلى الأماكن التى هو مطلوب لها يعتبر عمليه مكلفه ذلك لأن قش الأرز المتخلف بعد الحصاد يكون موزعا على الحقل يلزم جمعه وفى صوره منفوشه يصعب نقله. وبالتالى فإن الفلاحون يسارعون بالتخلص منه بالحرق لإخلاء الأرض وتجهيزها للمحصول القادم . ويمثل حرق قش الأرز أسرع و أسهل وسائل التخلص منه ولذلك فإن الفلاحون قد إعتادوا على حرق القش بمجرد الإنتهاء من عملية الحصاد حيث يتسبب ذلك فى تلوث الهواء بالدخان المتصاعد نتيجة الحرق. ولما تكررت تلك الأزمه البيئيه السنويه الخانقه فقد سعت الحكومه ولسنوات طويله لتوفير معدات كبس القش فى صورة بالات يسهل تداولها وتسويقها. ونتيجه للمجهودات المتواصله فقد أصبحت معدات كبس قش الأرز المصنعه محليا والمستورده متوافره للمزارعين .

وقد أجرى تقييم حقلى لمعدات الكبس التى وجدت متاحه لدى المزارعين . وقد إشتمل البحث على تقييم أربعة مكابس مستطيلة الباله إثنان منهم مجرورين بالجرار أحدهما محلى الصنع والأخر مستورد وإثنان من المكابس مستطيلة الباله أيضا أحدهما محلى والأخر مستورد . كما إشتملت الدراسه أيضا على تقييم مكبس إسطوانى الباله مستورد . ودلت نتيجة التقييم على أن معدل إلتقاط القش بالنسبه للمكابس المجروره بالجرار تراوح من ٢,٥٥ طن/الساعه للمحلى إلى ٣,٢٥ طن/الساعه للمستورد . كما أن معدل الكبس كان ١٠١ باله فى الساعه للمحلى إلى ١١٢ باله فى الساعه للمستورد . كما أن المكبسان المتحركان يعملان عند كفاءه متقاربه تقل عن ٧٠% . أما المكابس الثابته فقد تراوحت معدلات التغذيه من ٣,٨ طن/الساعه للمحلى إلى ٤,١ طن على الساعه للمستورد.

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*باحث أول بمعهد بحوث الهندسه الزراعيه

كما يعمل الكبس الثابت المحلى بمعدل ١٤٢ باله فى الساعه والمستورد بمعدل ١٥١ باله فى الساعه. وجميع المكابس المستطيلة الباله سواءا ثابته أو متحركه تنتج بالات بنفس الحجم وبوزن يتراوح من ١٩ إلى ٢١ كجم على الباله وكثافة الباله تتراوح من ١٣١ إلى ١٤٦ كجم/م^{3} . أما المكبس الإسطوانى الباله الذى تم إختباره مع تلك الآلات فإنه ينتج بالات أعلى كثافه ٠,٤٣٢ كجم/م^{3} وذات كتله كبيره تزن فى المتوسط ١٢٠ كجم/الباله الواحده وعمل عند كفاءه ٨٠% .

وقد دلت نتائج التقييم أيضا على أن المكابس المجروره بالجرار تعمل بكفاءه تناهز ٧٠% ومتوسط سعاتها الحقليه فى ظروف حقول التجربه كانت ١,١٩ فدان/الساعه للمكبس المجرور المحلى و ١,٣٤ فدان/ الساعه للمكبس المجرور المستورد . وأدت المكابس الثابته بكفاءه ٨٢% للمحلى و٨٥% للمستورد وبسعه حقليه تقارب ١,٥ فدان /الساعه لكلا المكبسين على إعتبار أن كمية المخلف ٢,٥ طن/فدان. أما المكبس الدورانى فقد أدى بمعدل ١,٤١ فدان/الساعه.