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DEVELOPMENT OF A PICKUP BALER FOR CHOPPING AND COMPRESSING CROP RESIDUES FOR PROCESSING NON-CONVENTIONAL FORAGES

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ABSTRACT

The aim of this study is to develop a John Deere Pickup Baler for chopping and compressing rice straw and stalks of wheat for Processing non-conventional Forages .This study was conducted by using a develop John Deere Pickup Baler to show the effect of straw moisture content and stalks of wheat are (36.0, 30.0,24.0 and 16.0 %), (28.0,25.0,22.0 and 18.0%) respectively ,machine forward speed (1.8,2.3,3.5 and 4.4 km/h) and different knives speed (18.0, 20.0, 23.0, and 26.0 m/s) on lengths of cut, Efficiency of straw bales, effective field capacity, energy requirements and unit cost .The results indicated that increase the forward speed from (1.8 to 4.4 km/h) at knives speed 26.0 m/se and straw rice moisture content of 30%, stalks of wheat.25.0%, w.b respectively tends to decrease lengths of cut of straw rice from (63.0 to 32.0 mm) and (60.0 to 28.0 mm) from stalks of wheat ,increasing effective field capacity from (0.61 to 1.14 and 0.655 to 1.4 fed/h.) respectively , decreasing energy required from (60.65 to 32.457 and 56.92 to 26.42 Kw.h/fed respectively) and decreasing unit cost from (87.06 to 46.58 and 81.7 to 37.93 LE/fed.), respectively. Also, straw moisture content of 36.0 % and stalks of wheat 28.0 %w.b. gave the highest values of chopping length, Efficiency of straw bales, energy requirements and unit cost at forward speed 1.8 km/h and knives speed 18 m/se

INTRODUCTION

In Egypt, there are about 2.0 millions feddans cultivated with rice each year and 2.0 – 3.0 millions feddans cultivated with wheat each year. This produces about 5 – 6 million tones of rice straw and 6 – 7 million tones of stalks wheat .(The Agricultural Magazine 2011).Given the importance of agricultural residues in contributing to food animal, especially waste rice straw and stalks of wheat crop they face shortage of fodder crops and enter into combinations of animal feed and poultry manufacturers but with the use of harvesting machines combine and A Pickup Baler**,** rice straw and wheat, sticks, straw, wheat stalks are long and hard on animals food it this way or take advantage of them and the farmer collected and re-threshing again to suit the food animal and this increases the costs of the operation or the burning of such waste in the field, and especially rice straw, and this is one of the most important causes of the current in the pollution of the environment because farmers have to in order to speed evacuation of the Earth and cultivation of the crop the next, and so the idea of this research to benefit from these residues by an amendment to the Pickup Baler John Deere to the process frame for these residues after taken from the field, composting, in bales, and this process, we maximize the benefit of the Pickup Baler a satellite to increase the number of hours of operation for use in more than one crop and reduce the costs required to process and store these bales in less space with the use time of need throughout the year .

(El-Danasory and Imbabi,1998)studied the mechanical pickup and 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 cost of using baler to pick up baling straw was less than the half cost of manual method.

(Tarek *et al*. 2001) developed a rice straw chopper. Their results showed that the productivity of the developed machine was 0.95 ton/h at 2000 rpm rotor speed and cut length of (1 - 9 cm) reached 95.235 from the total amount of cut residue.(Abd El-Mottaleb , 2002) found that the pick up baler requires minimum values of fuel , power and energy 7.5 lit/fed., 13.8kW and 20.3 kW.h/fed of rice straw, while maximum values were noticed with the use of both round baler 14lit/fed. 27kWand 38kW.h/fed of rice straw and stationary baler 28 lit/fed. 19 kW and 76 Kw.h/fed of rice straw.(El-Eraqi and El-Khawaga, (2003) ; Imbabi (2003) and Kamel *et al*. (2003) indicated that, the cutting length of crop residues is decreased by increasing feeding rate, cutter head drum speed, cutting knives number and decreasing the clearance between fixed and rotary knives.(Prasad and Gupta ,2005),stated that a knife approach angle of 32 degree was observed to be optimum corresponding to minimum value of energy requirements for cutting maize stalk.(Ebaid, 2006) used corn Sheller for chopping cotton and corn stalks. He mentioned that the cutting length category percentage at these condition was 63 and 45.4% in cut length of less than 3.35 cm for corn and cotton stalk residues, respectively. It was found that the chop operation cost was estimated at 13.33 LE/ton and 20 LE/ton for cutting corn and cotton stalk residues, respectively. (Metwally *et al*. 2006) developed and evaluate technically and economically the feeding and cutting mechanisms of chopping machine to be used for cutting the different crop residuals and pruning the fruit tree branches. They mentioned that increasing both feeding and cutting speeds tended to increase the actual capacities of chopping machine. The actual capacity of developed chopping machine increased by 28.6% when the cutting speed increased from 0.75 to 1.88m/s, while it decreased by 52.05% as a result to decrease the feeding speed from 1.22 to 0.28m/s with the cutting knife of serrated edge shape. (Arfa, 2007) modified the stationary thresher machine to become suitable for chopping and cut farm crop residues. Oval the slops area of 4 cm^2 drum speeds of 18.33 m/s, feeding rates of 1.5 ton/h, moisture content of 14.3% and concave clearance of 3 cm, resulting in cutting length percentage of 82.1, 85.6 and 80.1% less than 3.5 cm for rice straw, corn stalks and cotton stalks, respectively. Energy requirement were found to be 29.9, 27.3 and 25.8 kW.h/ton for rice straw, corn stalks and cotton stalks. The maximum operation cost was 25.0 LE/h and 17.0LE/ton for rice straw.

MATERIALS AND METHOD

The experimental work was carried out during season 2011-2012 at El – Morabin village, Kafr El – Sheikh Governorate. Was developed a John Deere Pickup Baler as shown in Fig 1 and plate 1 for the cutting and baling hay rice straw and stalks of wheat and the rest of the agricultural waste to suit the animal feed. Amendment was done in the following points.

a- worm gears have been modified in nutrition from the right side by removing part of the spiral auger on the length of 70 cm with the addition of four beams evenly distributed on the perimeter and is cut by knives as show in Figure 2 and 3.

b- Add a casual fixed number two down the upper part and a length of 70 cm mounted with knives, cut with knives, overlapping the top so you can chop a good agricultural waste from rice straw and stalks of wheat and succession.

c - Add the wave to enter the straw knives, hand pieces first before pressing the bales.

d - the possibility of taking into account the work of this amendment with a satellite the other pistons to maximize the benefit from this idea.

The obtained windrows of rice straw was Giza-177 variety after harvesting rice by Japanese combine harvester (2.1m operating width) were used. John Deere Pickup Baler was powered by a 65 hp Nasr tractor (48.5 Kw).

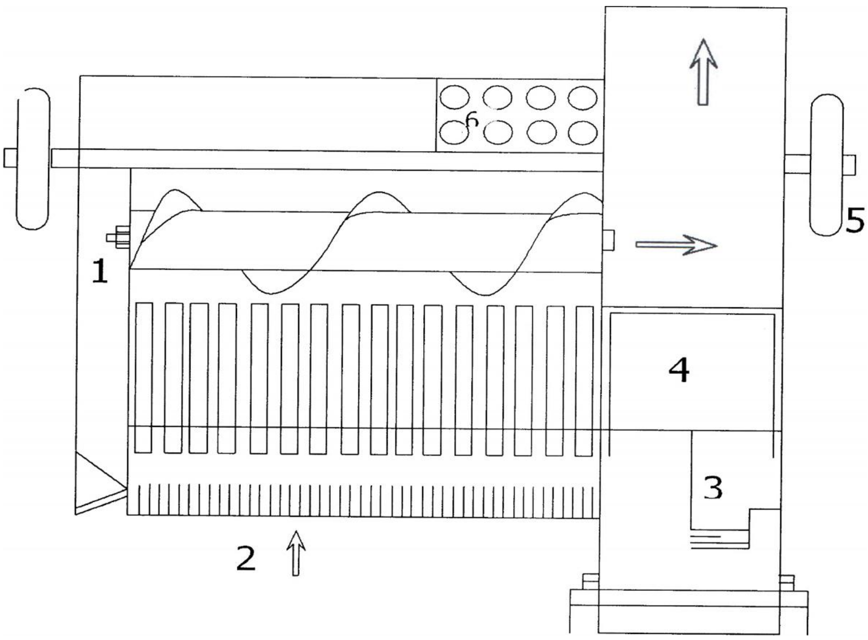


Fig.1: Plan view of pick up baler

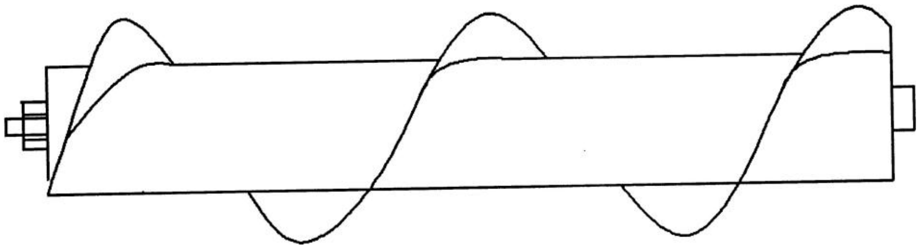
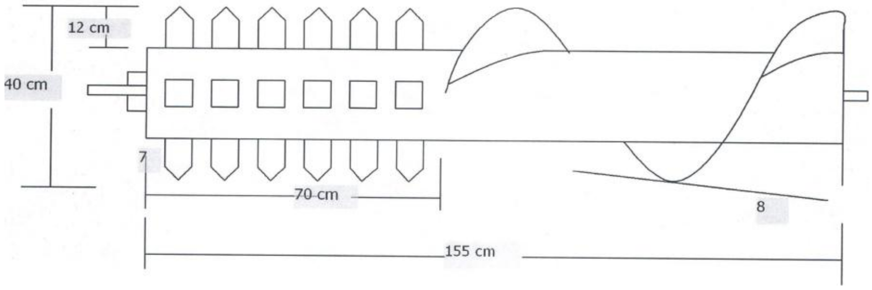
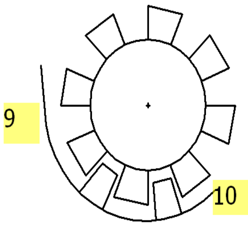


Fig.2: The part by amendment



plan view



side view

Part no.	Part name	Part no	Part name
1	Auger	6	String
2	Pick up	7	Knife cutting
3	Bale	8	Plate
4	chamber	9	Concave
5	Ram	10	Casual iron
	(piston)		
	Tires		

Fig.3: Plan and side view of the part after amendment

Equipment:

The John Deere Pickup Baler was mounted on the 65 hp NASR tractor (48.51 kW) during the work in the present study. The main components of the John Deere Pickup Baler are shown in Fig. 1 and plate 1 the technical specification are shown in table 1.

Table 1: Technical specification of the John Deere pickup baler model 338

Item	Specification
Bale size	
Height x width (cm)	36 x 46
Length (cm) adjustable	30.5 to 127
Pickup	
Pickup width (cm)	187.9
Tooth Bars / Teeth	6 bars , 156 teeth
Auger	
Diameter (cm)	41
Length (cm)	154.9
Plunger	
Strokes/ minute	80
Stroke length (cm)	76.2
Baler Dimensions	
Length w/long tongue. (cm)	576.5
Width (cm)	274.3
Height (cm)	170.2
Weight (kg) Empty	1272
Tractor Requirements	
P.T.O. Speed, r.p.m.	540
Minimum P.T.O., H.P	35

Plate 1: John Deere Pickup Baler

Measurements:

The following items were measured during evaluating the Pick up baler John Deere under the study parameters:-

1- Theoretical and actual lengths of cut:

The theoretical length of cut, L_{th} was calculated using the following equation according to **Srivastava, et. al. 1995.**

$L_{th} = 60000\, V_f / \eta_c\, \lambda_k$, mm ---1

Where:

V_f = Feed velocity, m/s (= peripheral speed of feeding rolls).

η_c = Cutter head rotational speed, rpm.

λ_k = Number of knives on the cutter head.

After each chopping treatment, random samples (1 kg each) were taken from chopped material the laboratory and separated to determine the actual mean of cutting length (Lac). Each cutting length in the sample was weighed and calculated as a percentage in proportional to the total weight of the sample.

2- The effective field capacity.

The effective field capacity (Ef_c) was calculated by using the following formula ; (Kepner *et al*., 1982).

$$Ef_c = 1/T \quad \text{------------------------------} \quad 2$$

Where:

Ef_c = Effective field capacity, fed/h ;

T = total time ($t + t_1 + t_2 + t_3 +$ ------) ;

t = theoretical time;

$t_1 + t_2 + t_3$ = the total time lost during operation;

t_1 = time lost for turning ;

t_2 = time lost for repining and

t_3 = time lost for for adjusting the machine .

4- John Deere Pickup Baler efficiency:

The John Deere Pickup Baler efficiency (Ec) was calculated by using the following formula, **.**

$$\frac{T.n.b - N.b.l}{T.n.b} X100 \quad E_C = \quad 3$$

Where:

T .n .b = Total number of bales / fed..

N .b .l = Number of bales looses /fed.

5- Required power :

Energy requirements estimated by using the following formula, Embaby 1985.

$$Kw, \text{-------}4 \frac{1}{1.36} \times \frac{1}{75}) \; \rho_F \times L.C.V. \times 427 \times \eta_{th} \times \eta_m \times \frac{1}{3600} \; E_p = (F_c \times$$

Where:

E_p = Power required;

F_c = the fuel consumption, L/h;

ρ_F = the density of fuel, 0.85 kg/l ;

L.C.V = the lower calorific value of fuel, 10000 k cal/kg;

η_{th} = the thermal efficiency of engine, 35% for diesel engine.

427 = thermo – mechanical equivalent, kg.m/k.cal, and

η_m = the mechanical efficiency of engine, 80% for diesel engine.

Energy requirement for baling

Energy requirement was calculated using the following equation :

$$\text{Energy requirement (Kw.h./fed)} = \frac{Balingpower, kW}{Acualfield\ capacity,\ fed / h} \quad ......5$$

6- Estimation baling cost:

The total hourly cost of baling rice straw and stalks of wheat using the John Deere Pickup Baler could be estimated by the following equation according to EL- Awady, 1978 as follows:

$$C= \frac{p}{h} (\frac{1}{a} + \frac{i}{2} + t + r) + (1.2\ W . S. F) + \frac{m}{144} \text{ ----------------------------6}$$

where;

cost per hour of operation, L.E/h; = **c**

P = estimated price of the machine, 40000 L.E for chopper machine and price of the tractor, 75000 L.E. ;

h= is the estimated yearly – operating hours 1440 h (6 month * 30 day * 8 hours)

L = life expectancy of the machine, 10 years;

I = annual interest rate, 12%;

α= annual taxes and overheads, 0.03%;

r = annual repair and maintenance rate, 10%;

1.2 = correction factor for rated load ratio and lubrication;

w = engine power, 65 hp;

f = specific fuel consumption,0.25 L/hp.h ;

b = Is the monthly salaries, 500 L.E.; 144 is the estimated working hour's per month and,.

u = fuel price, 1.25 L.E/L.

Cost of using shredder :C_1= 9.44 L.E./h. and the cost of using common tractor;

C_2 = 43.67 L.E./h. and the total cost of the operating = C_1 + C_2 = 9.44 + 43.67 = 53.11 L.E./h.

RESULTS AND DISCUSSION

Length of cut:

Results of cutting length of rice and wheat straw as affected by different variables were illustrated in Figures 4 and 5. It is obvious that, increasing the baler forward speed from1.8 to 4.4km/h, at moisture content of 36 and 28%w.b. and knives speed of 26m/s tends to decrease the cut lengths from 7.4 to 3.6cm and 6.7 to 3.1cm during baling rice and wheat straw respectively. Generally, the highest value of lengths cut of 9.8 and 8.0cm was obtained at 1.8km/h forward speed, 18m/s knives speed and moisture content of 36 and 28% for rice and wheat straw, respectively. While the lowest value of 2.72 and 2.0cm was obtained at 4.4km/h forward speed, 26m/s knives speed and moisture content of 16 and 18%w.b. for rice and wheat straw, respectively.

Efficiency of straw bales:

Results of straw bales efficiency for rice and wheat straw as affected by different investigated variables are illustrated in Figures 6 and 7. It is obvious that, increasing the baler forward speed from1.8 to 4.4km/h, at moisture content of 36 and 28%w.b. and knives speed of 26m/s, tends to decrease the straw bales efficiency from 90.1 to 87.2 and 87.5 to 82.8% during baling rice and wheat straw, respectively. Generally, the highest values of straw bales efficiency of 92.0 and 89.7% were obtained at 1.8 km/h forward speed, 18m/s knives speed and moisture content of 36 and 28%w.b. for rice and wheat straw, respectively. While the lowest values of 85.6 and 79.9% were obtained at 4.4km/h forward speed, 26m/s knives speed and moisture content of 16 and 18 %w.b. for rice and wheat straw, respectively.

Chopping length and Effective field capacity:

Results of chopping length and effective field capacity of rice and wheat straw as affected by different variables are shown in Figures 8 and 9. It is clear that, increasing the baler forward speed from1.8 to 4.4km/h, at moisture content of 16 and 18%w.b. and knives speed of 26m/s, tends to increase the effective field capacity from 0.63 to 1.16 and 0.66 to 1.41fed/h during baling rice and wheat straw, respectively. Generally, the highest value of effective field capacity of 1.16 and 1.41fed/h was obtained at 4.4km/h forward speed, 26m/s knives speed and moisture content of 16 and 18% with rice and wheat straw, respectively. While the lowest value of 0.585 and 0.636fed/h was obtained at 1.8km/h forward speed, 18m/s knives speed and moisture content of 36 and 28% for rice and wheat straw, respectively.

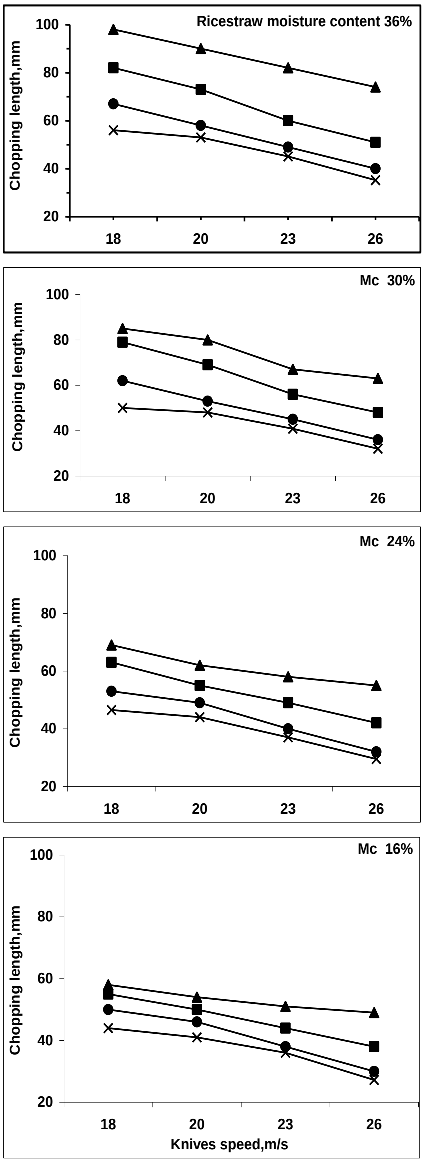
Energy requirements:

Results of energy requirements of rice and wheat straw as affected by different variables are depicted in Figures 10 and 11. It is revealed that, increasing the baler forward speed from 1.8 to 4.4km/h, at moisture content of 24 and 22%w.b. and knives speed of 26m/s, tends to decrease the energy requirements from 59.67 to 32.17 and from 56.48 to 26.33kWh/fed, during baling rice and wheat straw, respectively. Generally, the highest values of energy requirements of 63.24 and 58.17kWh/fed were obtained at 1.8km/h forward speed, 18m/s knives speed and moisture content of 36 and 28 % for rice and wheat straw, respectively. While the lowest values of 31.89 and 26.24 kWh/fed were obtained at 4.4km/h forward speed, 26m/s knives speed and moisture content of 16 and 18% for rice and wheat straw, respectively.

Unit cost:

Results of unit cost for rice and wheat straw as affected by different variables are shown in Figures 12 and 13. It is clear that, increasing the baler forward speed from1.8 to 4.4km/h, at moisture content of 36 and 28%w.b. and knives speed of 26m/s, tends to decrease the unit cost from 88.51 to 47.0 and from 82.34 to 38.07L.E./fed during baling rice and wheat straw, respectively. Generally, the highest value of unit cost of 90.87 and 83.5L.E./fed was obtained at 1.8km/h forward speed, 18 m/s knives speed and moisture content of 36 and 28% for rice and wheat straw, respectively. While the lowest value of 45.78 and 37.66L.E./fed was obtained at 4.4km/h forward speed, 26m/s knives speed and moisture content of 16 and 18% for rice and wheat straw, respectively.

Machine forward speed -▲- 1.8 -■- 2.3 -●- 3.5 -x- 4.4 km/h



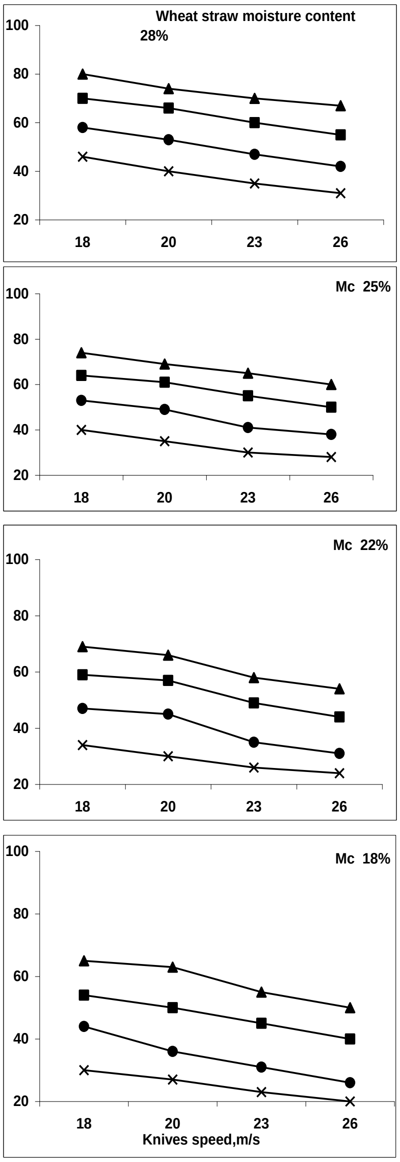
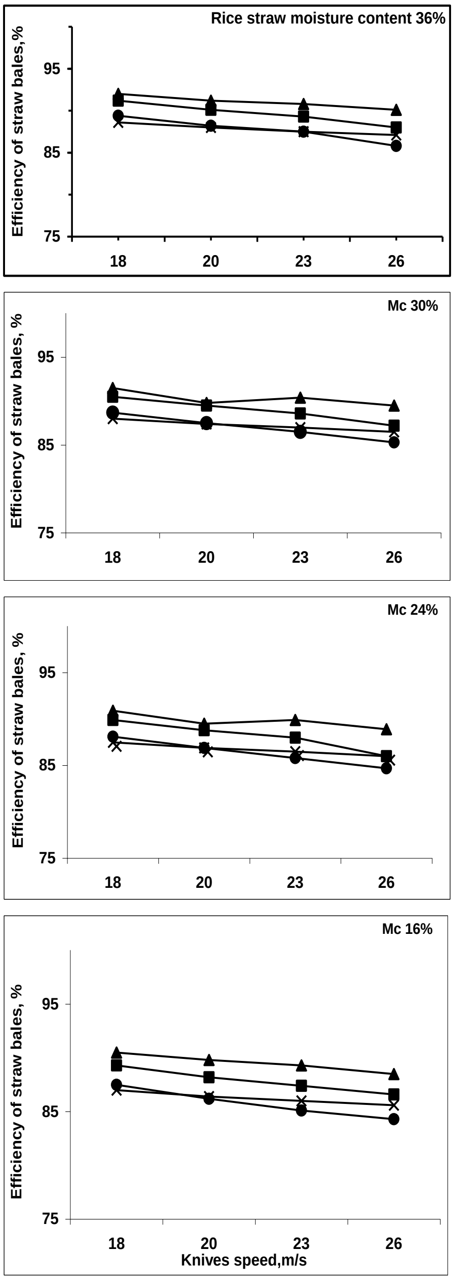


Fig.4 :Effect of knives speed and forward speed on chopping length at different moisture content of rice straw.

Fig.5: Effect of knives speed and forward speed on chopping length at different moisture content of wheat straw.

Machine forward speed -▲- 1.8 -■- 2.3 -●- 3.5 -x- 4.4 km/h



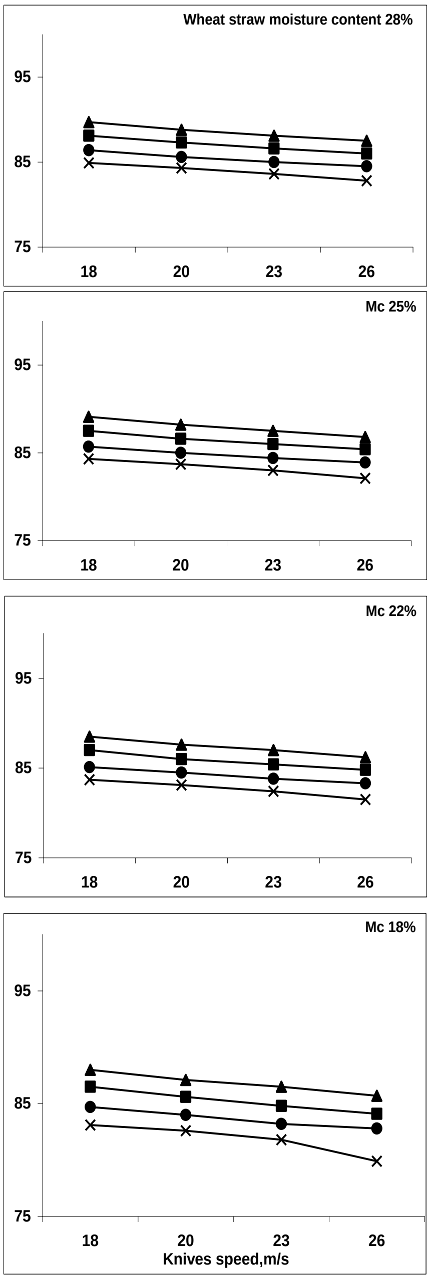


Fig. 6: Effect of knives speed and forward speed on efficiency of straw bales at different moisture content of rice straw.

Fig.7: Effect of knives speed and forward speed on efficiency of straw bales at different moisture content of wheat straw.

Machine forward speed -▲- 1.8 -■- 2.3 -●- 3.5 -x- 4.4 km/h

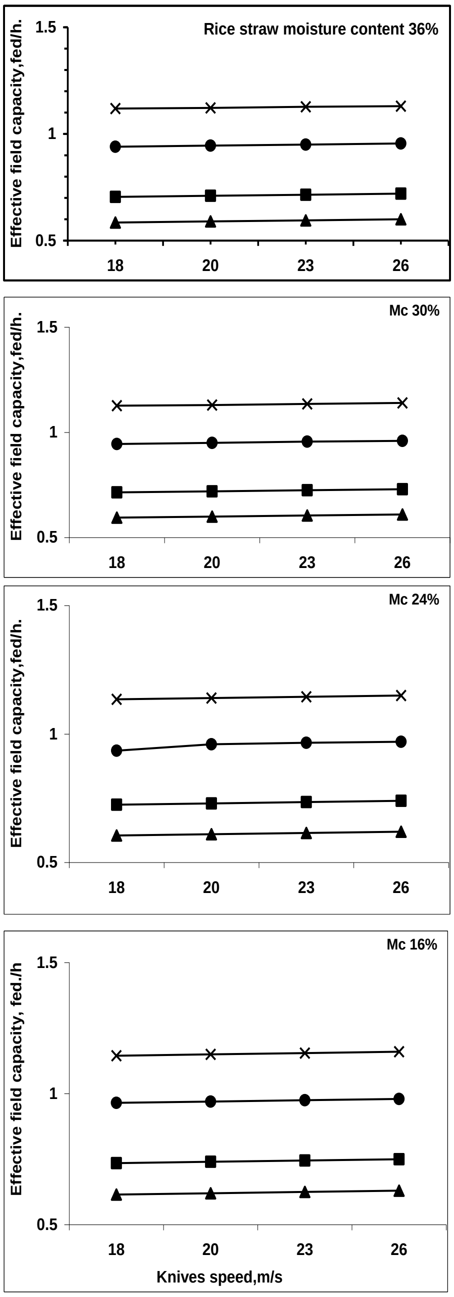


Fig. 8 : Effect of knives speed and forward speed on effective field capacity at different moisture content of rice straw.

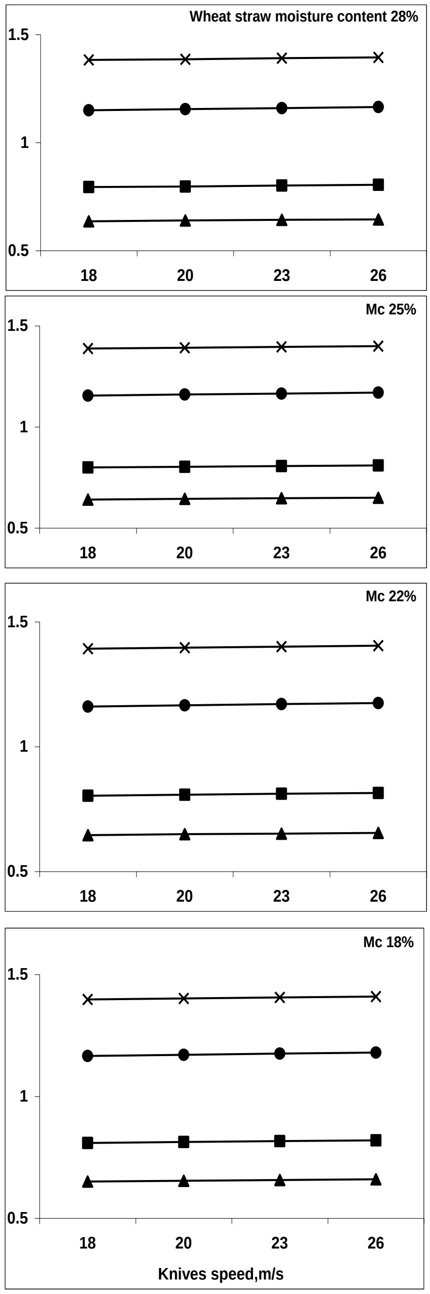


Fig.9: Effect of knives speed and forward speed on effective field capacity at different moisture content of wheat straw.

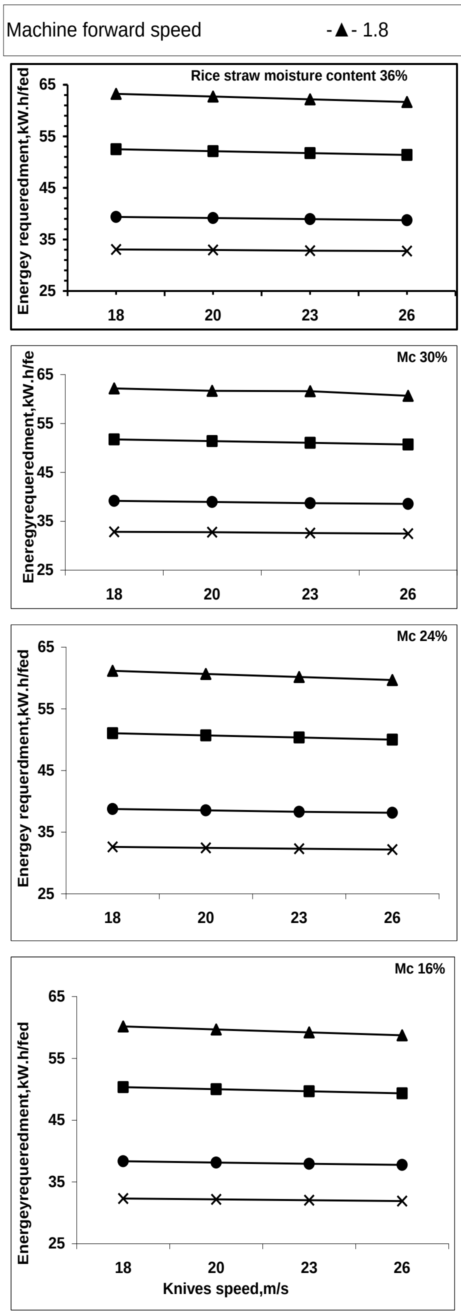


Fig. 10:Effect of knives speed and forward speed on energy requerdment at different moisture content of rice straw.

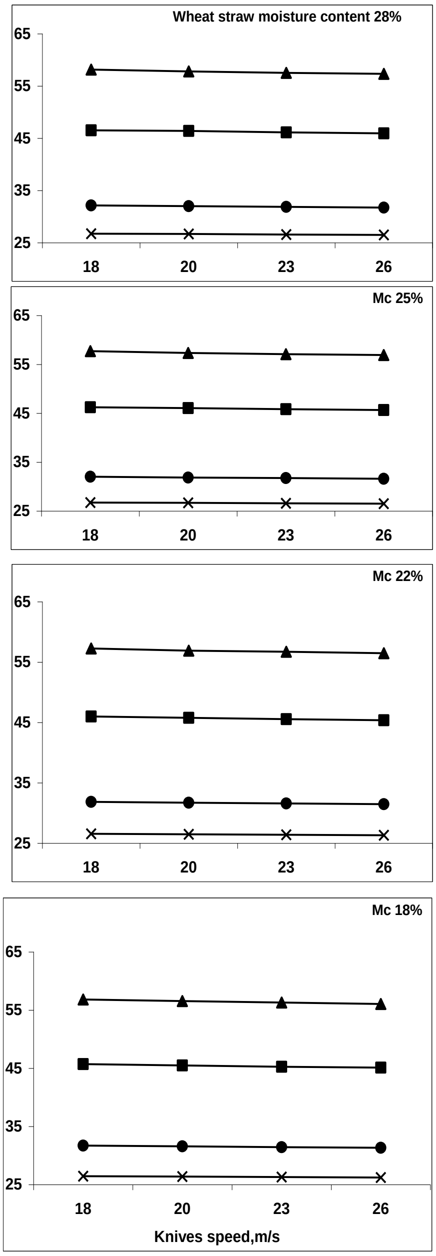


Fig.11:Effect of knives speed and forward speed on energy requerdment at different moisture content of wheat straw.

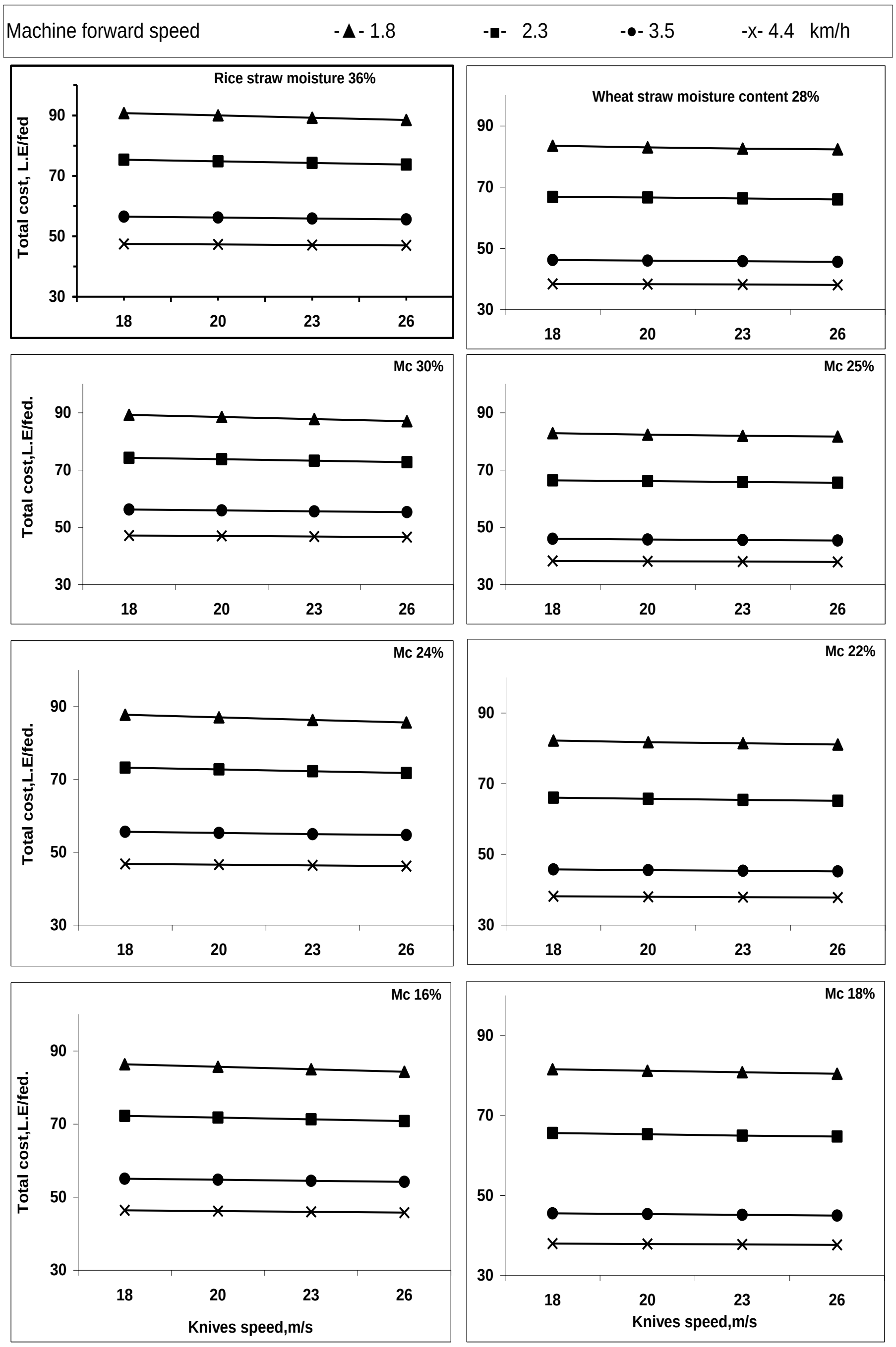


Fig.12 :Effect of knives speed and forward speed on total cost at different moisture content of rice straw.

Fig.13: Effect of knives speed and forward speed on total cost at different moisture content of wheat straw.

Conclusions

From the abovementioned results, the following conclusions could be derived:

- The amount of small cutting lengths increased as the knives and forward speed were increased. While by decreasing the percentage of straw small lengths, an increase of moisture content with rice and wheat straw was occurred, respectively.
- The percentage of straw bales efficiency decreased as the knives and forward speed were increased. While by decreasing the percentage of straw bales efficiency, a decrease of moisture content with rice and wheat straw was occurred, respectively.
- The effective field capacity decreased as the knives and forward speed were decreased. While by increasing the percentage of effective field capacity, a decrease of moisture content with rice and wheat straw was occurred, respectively.
- Energy consumed was increased by increasing moisture content, decreasing knives and forward speeds for both rice and wheat straw.
- Value of unit cost decreased as the knives and forward speed were increased. While by decreasing the value of unit cost, a decrease of moisture content with rice and wheat straw was occurred, respectively.

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تطوير مكبس لاقط لتقطيع وكبس مخلفات المحاصيل لتصنيع الأعلاف غير التقليدية

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****قسم الهندسة الزراعية – جامعة كفرا لشيخ**

نظرا لأهمية المخلفات الزراعية في المساهمة في الغذاء الحيواني وخصوصا مخلفات قش الأرز وسيقان محصول القمح فهما يواجها نقص محاصيل الأعلاف ويدخلا في تركيبات الأعلاف الحيوانية والثروة الداجنة المصنعة ولكن مع استخدامات آلات الحصاد الجامعة و مكابس قش الأرز والقمح فأن أعواد القش وسيقان القمح تكون طويلة ويصعب على الحيوانات الغذاء عليها بهذه الصورة أو الاستفادة منها ويقوم الفلاح بجمعها وإعادة دراسها مرة أخرى حتى تناسب الغذاء الحيواني وهذا يزيد من تكاليف العملية أو يقوم بحرق هذه المخلفات في الحقل وخصوصا قش الأرز وهذا يعتبر من أهم الأسباب الحالية في تلوث البيئة لأن الفلاح يضطر إلى ذلك لسرعة إخلاء الأرض و زراعة المحصول التالي و لذلك قامت فكرة هذا البحث للاستفادة من هذه المخلفات بواسطة إجراء تعديل على مكبس جون دير ليقوم بعملية فرم لهذه المخلفات بعد ألتقاطها من الحقل وكبسها في بالات وبهذه العملية نقوم بتعظيم الاستفادة من المكابس اللاقطة بزيادة عدد ساعات تشغيلها باستخدامها في أكثر من محصول وتقليل التكاليف اللازمة لهذه العملية وتخزين هذه البالات في حيز اقل مع استخدامها وقت الحاجة طوال العام وقد أجريت التجارب بقرية المرابعين مركز ومحافظة كفرا لشيخ في موسم ٢٠١١ /٢٠١٢ تحت تأثير المتغيرات الآتية:

١- ثلاث سرعات أمامية للآلة (١.٨ – ٢.٣ – ٣.٥ – ٤.٤ كم / ساعة) .

٢- أربع سرعات دورا نية لسكاكين الفرم (١٨ – ٢٠ – ٢٣– ٢٦م/ث)

٣- أربع محتويات رطوبة لقش الأرز وسيقان القمح على أساس رطب هما على التوالي (١٦ – ٢٤ – ٣٠ - ٣٦ %) و (١٨ – ٢٢ – ٢٥ – ٢٨ %) .

وقد كانت أهم النتائج المتحصل عليها كما يلي :-

١- إن أقل قيمة لأطوال القش المقطوع كانت ٢٧.٢ و ٢٠مم عند محتوى رطوبى ١٦ و ١٨% و سرعة سكاكين التقطيع ٢٦م/ث و سرعة أمامية ٤.٤ كم / ساعة مع قش الأرز وسيقان القمح على التوالي

٢- ووجد أن اعلي قيمة لتكاليف العملية هي ٩٠.٧٨ و ٨٣.٥ جنية / فدان عند سرعة أمامية ١.٨ كم/ساعة وسرعة سكينة القطع ١٨ م/ ث ومحتوى رطوبة ٣٦ و ٢٨ % لقش الأرز وسيقان القمح على التوالي .

٣- أوضحت النتائج إن اعلي قيمة لوحدة الطاقة المستهلكة كانت (٦٣.٢٤ و ٥٨.١٧ كيلووات.ساعة/فدان) عند سرعة أمامية ١.٨ كم/ساعة وسرعة سكينة القطع ١٨ م/ ث ومحتوى رطوبة ٣٦ و ٢٨ % لقش الأرز وسيقان القمح على التوالي .

٤- ينصح باستخدام المكبس المطور لقلة نكاليفة بالمقارنة بالعمليات الأخرى بالإضافة لتوفير الوقت والجهد لان عملية التقطيع والكبس في بالات تتم في عملية واحدة بينما تتم في أكثر من عملية في المكابس التقليدية.

قام بتحكيم البحث

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