

## **EFFECT OF SOME OPERATING FACTORS OF RESIDUES CHOPPER ON CORN STALKS CHOPPER QUALITY**

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### **ABSTRACT**

Crop residues are one of the most problems, which face the Egyptian farmer. The quantity of crop residues in Egypt reached about 18.7 to 25 million Mg per year. The performance of chopping machine was tested under the following parameters. A) Four cutter head speeds ( 22.1, 25.6, 29.2 and 35.3 m/s ), B) Three number of knives were ( 2, 4, and 8 knives ) and C) Three levels of corn stalks moisture contents were ( 35.0, 45.0, and 65.0 %). The performance of chopping machines as chopping length, degree of destruction, machine productivity and energy were measured.

The final results of this study could be summarized as follows:

Generally, increasing the cutter head speed from (22.1 to 35.3 m/s) tend to increase percentage of chopping length 0.5 to 2.0 cm from (50 to 60 %), degree of destruction from ( 28.7 to 38.2 % ) , machine productivity from (1.32 to 2.81 Mg/h), useful power from (2.19 to 3.86 kW), and with decreasing the unit energy required from (1.87 to 1.37 kW.h/Mg) and chopping machine cost from (16.33 to 7.22 L.E/ Mg ) at number of knives 2 and corn stalk moisture content of 65.0 %.

### **INTRODUCTION**

During the summer season, most of the Egyptian farmers feed their livestock on very poor quality roughage, such as rice and wheat straw. The decrease of forage crops during this period seems to be a serious problem in the nutritional requirements of animal. Beef, dairy cattle and other types of livestock will remain in better condition during the summer season if they receive a succulent feed. There are a little green pastures in the summer such as feed must be grown, harvested, processed and preserved in a silo so that it will be available when needed. In Egypt corn is the principal silage crop. Silage process was hoped to participate in solving the serious problems of feed shortage of livestock.

Pasikatan *et al.* (1997) study the chopper performance with three materials (napier grass, corn stalks and rice straw) was satisfactory. For corn stalks indicated the best setting was 1050 rpm at 2.0 mm clearance. This setting gave 1062 kg/h capacity and specific energy of 1.7 kW.h/Mg.

Khader (1997) studied the interaction effect between different speeds of cutter head and number of knives for cutting some field crop residues such as cotton stalks, bean stalks and rice straw and its effect on power requirement and cutting length. He found that the cutting length decreased by increasing number of knives and cutter head drum speed. The recommended cut length for preparing animal fodder ranged from 1.5 to 3.0 cm, with obtaining silage may be produced by using cut length ranged from 3.0 to 6.0 cm.

Kholief *et al.* (1998) using a stationary chopper to show the effect of corn moisture content , cutter head speed and feed mechanism speeds on

chopping lengths, unit energy and machine productivity. They found the maximum value of unit energy was 2.081kW.h/Mg at moisture content of 40.22%, cutter head and feed mechanism speed of 27.65m/s and 0.41 m/min, respectively. Meanwhile, the minimum value was 0.85 kW.h/Mg at moisture content of 62.82% , cutter head and feed mechanism speeds of 20.73m/s and 1.45m/min, respectively.

El-Khateeb (2001) indicated that the increasing the forward speed for chopper corn stalks by rotary mower from (2.51 to 4.51 km/h) tends to increase the stubble height from (8.20 to 12.0 cm), effective field capacity from (0.6 to 1.4 fed/h), and power requirement from (11.06 to 17.06kW), and decrease the cutting efficiency from (95.0 to 89.0%), degree of destruction from (35.0 to 21.0%) and cutting energy from (18.43 to 12.19kW.h/fed).

El-Ashhab *et al.* (2003) used four crop residues were in values of ( corn stalks, corn stover, rice straw and alfalfa) performance of the chopper before modification. Power consumption was 1,740, 1,330, 1,580 and 1,350 kW for each of the four materials, respectively. Corresponding chopping energy were 0.775, 0.556, 0.310 and 0.880 kg/Wh for the four materials , respectively.

Lotfy (2003) develop and evaluate a machine for cut and throw agricultural residues. He found that the machine output was (1822, 2128 and 1976 kg/h), average cut length was (2.8, 2.5 and 2.6 cm), energy requirements was (12.14, 11.45 and 11.03kW.h/Mg) and operating cost was (8.13, 6.80 and 7.02 L.E/Mg) for cutting rice straw, cotton stalks and corn stalks, respectively, under cutting speed 43.35m/s, feeding speed 2 m/s and cutting clearance 2 mm.

Musa *et al.* (2004) developed of combination unit for cutting and chopping corn stalks. He found the maximum percentage of cutting efficiency (96.67%) and chopping efficiency of (86.91%) were obtained at forward speed of 0.9 km/h and knife revolving speed 920 rpm (72.25m/s).

Metwally *et al.*(2006) developed a chopper machine for agricultural residual. They found that the increase of cutter head speed from 0.75 to 1.88 m/s tends to increase the chopping length by 24.1 and 60.5 % for serrated and straight-edge shapes.

El-Khateeb and El-Keway (2012) used two different types of shapes cutting knives {smooth-edge (Original knives) and serrated-edge (Modified knives)}. They found that the average values of the chopper productivity of (1.30, 1.40, 1.60 and 1.80 Mg/h) and (1.2, 1.3, 1.4 and 1.6 Mg/h) were obtained when using type of cutting knives serrated-edge under cutter head speed of 900, 1050, 1200 and 1500rpm at moisture content of 30 % and 22.0% for cotton stalks and rice straw, respectively.

the objectives of this research work, the residues chopper was used for chopping corn stalks under the following variables:

- A)** Four cutter head speed of (22.1, 25.6, 29.2, and 35.3 m/s).
- B)** Three number of knives of (2,4, and 8 knives) and
- C)** Three levels of corn stalks moisture contents of (65.0, 45.0, and 35.0 %)

## MATERIALS AND METHODS

The experimental work was carried out at research farm of Rice Mechanization Center, Meet El Deba, Kafr El- Sheikh, Governorate. During summer season 2012. To evaluate the operating parameters affecting on power and energy requirements for chopping and to fulfill the objectives of this research work, the residues chopper was used for chopping corn stalks under the following variables:

- A)** Four cutter head speed of (22.1, 25.6, 29.2, and 35.3 m/s).
- B)** Three number of knives of (2, 4, and 8 knives) and
- C)** Three levels of corn stalks moisture contents of (65.0, 45.0, and 35.0 %)

These variables were studied for the following determinations; machine productivity, chopping length, chopping power requirements, degree of destruction of stalk borer and chopping cost for the corn stalks variety one-cross 10.

### Equipment:

The stationary forage chopper was mounted on the 65 hp NASR tractor (48.5 k.W) by three hatch points during chopping corn stalks in the present study. The main components of this chopping are sketched in Figure (1) and technical specifications of this chopper are summarized in Table 1.

**Table 1: Machine Specifications:**

Item	Detail
<b>Model</b>	ALTIC
<b>Country</b>	EGYPT
<b>Power source</b>	P.T.O. Shaft (65 H.P. 540 r.p.m.)
<b>Feeding system</b>	Manual (axel direction with cutter head)
<b>Number of knives on cutter head</b>	2, 4, and 8 knives
<b>Flywheel diameter</b>	70 cm
<b>Cutting r.p.m. and Feeding r.p.m.</b>	1620 and 270
<b>Upper feed drum</b>	Scraper and diameter is 20 cm
<b>Lower feed drum</b>	Flat and diameter is 12 cm
<b>Maximum height</b>	275 cm
<b>Maximum length</b>	155 cm
<b>Maximum width</b>	160 cm

### Machine performance determination:

#### Machine Productivity:-

Was calculated by using the following formula by Mady, 1999.

$$P = W \times 3600 / T, \text{ Mg/h}, \dots\dots\dots 1$$

where:

- P = productivity in Mg/h;
- W = mass of the sample in Mg, and
- T = time in sec.

#### Degree of destruction of the stalk borer:-

Was calculated by using the following formula by Hanna *et al.*1985.

$$\text{Degree of Destruction, \%} = F - L / F \times 100, \dots\dots\dots 2$$

where:

F = Number of infested corn stalks borer before chopping and

L = Number of infested corn stalks borer after chopping operation

**Required power :**

Chopping energy requirements estimated by using the following formula, Embaby 1985.

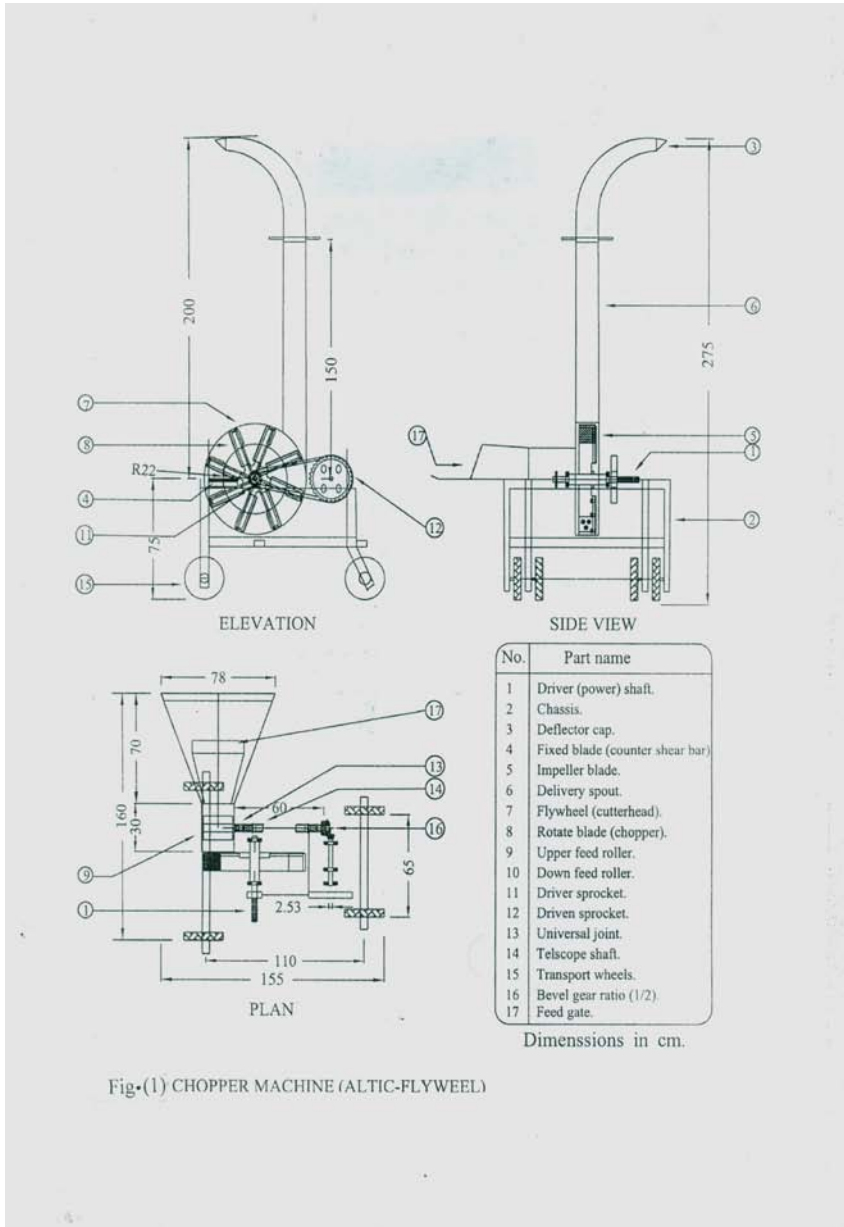


Fig.(1) CHOPPER MACHINE (ALTIC-FLYWEEL)

$$E_p = (F_c \times \frac{1}{3600}) \rho_f \times L.C.V. \times 427 \times \eta_{th} \times \eta_m \times \frac{1}{75} \times \frac{1}{1.36}$$

**kW, .....3**

where;

$E_p$  = power required ;

$F_c$  =the fuel consumption, L/h;

$\rho_f$  = the density of fuel, 0.85 kg/l;

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

$\eta_{th}$  = the thermal efficiency of engine, 35% for diesel engine;

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

$\eta_m$  = the mechanical efficiency of engine, 80% for diesel engine.

**Useful Power = power on load – power unload, kW, .....4**

$$\frac{\text{Energy}}{\text{usefulPower}(kw)} \quad \text{unit} \quad =$$

$$\frac{\text{machineproductivityMg / h}}{, kW.h / Mg, .....5}$$

**Estimation chopping cost:**

The total hourly cost of chopping corn stalks using the forage chopper could be estimated by the following equation according to EL-Awady, 1978 as follows:

$$C = \frac{p}{h} \left( \frac{1}{L} + \frac{i}{2} + a + r \right) + (0.9w \times f \times u) + b ,$$

.....6

where;

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

P = estimated price of the machine, 8000 L.E for chopper machine ;

h = estimated yearly hour operation ,1000 for chopper machine;

L = life expectancy of the machine, 10 years;

i = annual interest rate, 10 %;

a = annual taxes and overheads, 2 %;

r = annual repair and maintenance rate, 18 %;

0.9 = correction factor for rated load ratio and lubrication;

w = engine power, 65 hp;

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

b = hourly labor wage, 4 L.E/h, and

u = fuel price, 0.90 L.E/L .

## RESULTS AND DISCUSSION

### 1-- Chopping length (cm):

Data and results of chopping length of stalks as affected by different variables are summarized in Table 2. The percentage of small chopping length increased at the cutter head speed m/s was increased with constant number of knives and corn stalks moisture content.

At chopping machine 65 % corn stalk moisture content and number of knives 2, by increasing cutter head speed from 22.1 to 35.3 m/s it was found that percentage of chopping length changed from ( 50 to 60 %, 30 to 26 % and 20 to 14 %) which cut stalk lengths of (0.5 to 2 cm, 2 to 4 cm and bigger than 4 cm), respectively.

At chopping machine 22.1 m/s of cutter head speed and corn stalk moisture content of 65 %, when the number of knives increased from 2 to 8 knives, the percentage of chopping length changed from (50 to 80 %, 30 to 20 % and 20 to 3 %) at cutting stalk lengths of (0.5 to 2 cm, 2 to 4 cm and bigger than 4 cm), respectively. The cut stalk lengths of 4 to 5 cm did not appear at number of knives 8.

At chopping machine cutter head speed of 25.6 m/s and number of knives of 2, when the corn stalks moisture content increased from 35 % to 65 %, the percentage of chopping length changed to from (46 to 54 %, 33 to 29 % and 21 to 17 %) at cutting stalk lengths of (0.5 to 2 cm, 2 to 4 cm and bigger than 4 cm), respectively, as summarized in Table 2.

### 2- Chopper productivity (Mg/h):-

The results of chopper productivity are shown in Figure 2. From these results it could be indicated that an increase in cutter head speed, number of knives and corn stalks moisture content results in an increment in the chopper productivity ,Mg/h.

The average values of the chopper productivity of 1.56, 1.95, 2.63 and 3.53 Mg/h were obtained when using number of knives 8 on chopper cutter head under cutter head speed of 22.1, 25.6, 29.2 and 35.3 m/s at corn moisture content of 65 %.

### 3- Degree of destruction of stalk borer (%):-

The degree of destruction is affected by cutter head speed, number of knives and corn stalk moisture content as shown in Figure 3. It is noticed that the following cutter head speed of 22.1, 25.6, 29.2 and 35.3 m/s, gave the degree of destruction of 50.9, 55.8, 65.1 and 72.5 %, respectively, The other number of knives 2 and 4 gave the same above mentioned trend. Also, it can be concluded that increasing corn stalk moisture content from 35 to 65 % tends to decrease the degree of destruction from 72.5 to 42.3 %. These results agreed with that obtained by El-Khateeb, 1991.

**Table 2 :- Effect number of knives and cutterhead speed on cutting stalk length at different corn stalks moisture content.**

Moisture content, %	Cutter head speed, m/s.	Cut stalk of lengths, cm	Number of knives		
			2	4	8
65.0	22.1	0.5 – 2	50 %	69 %	80 %
		2 – 4	30	28	20
		> 4	20	3	--
	25.6	0.5 – 2	54	73	86
		2 – 4	29	27	14
		> 4	17	--	--
	29.2	0.5 – 2	57	77	92
		2 – 4	28	23	8
		> 4	15	--	--
	35.3	0.5 – 2	60	82	99
		2 – 4	26	18	1
		> 4	14	--	--
45.0	22.1	0.5 – 2	46 %	66 %	76 %
		2 – 4	34	24	24
		> 4	20	10	--
	25.6	0.5 – 2	48	69	82
		2 – 4	32	31	18
		> 4	20	--	--
	29.2	0.5 – 2	52	74	88
		2 – 4	30	26	18
		> 4	18	--	--
	35.3	0.5 – 2	56	76	95
		2 – 4	27	24	5
		> 4	17	--	--
35.0	22.1	0.5 – 2	42 %	64 %	71 %
		2 – 4	35	27	29
		> 4	23	9	--
	25.6	0.5 – 2	46	66	78
		2 – 4	33	34	22
		> 4	21	--	--
	29.2	0.5 – 2	49	71	84
		2 – 4	31	29	16
		> 4	20	--	--
	35.3	0.5 – 2	54	73	90
		2 – 4	28	27	10
		> 4	18	--	--

**4- Useful power (kW):-**

Results of useful power required to chopping corn stalks as affected by different variables are shown in Figure 4. At number of knives of 2 and corn stalk moisture content of 65 %, when the cutter head speed increased from 22.1 to 35.3 m/s, it was found that useful power increased from 2.19 to 3.86 kW, due to increase of fuel consumption. Chopping machine at cutter head speed of 22.1 m/s and 65 % moisture content, when the number of knives increased from 2 to 8 knives the useful power increased from 2.19 to 2.94 kW, due to increase of fuel consumption by increasing number of knives.

Chopping machine at cutter head speed of 22.1 m/s and number of knives 2, when the corn stalks moisture content increased from 35 to 65 %, the useful power decreased from 5.81 to 2.19 kW.

**5- Unit energy (kW.h/Mg):-**

The unit energy (kW.h/Mg) is the best indicator to show the effect of these parameters. Figure 5 and Table 3 shown the unit energy increased as the number of knives was increased at constant cutter head speed and corn stalks moisture content. By increasing the number of knives from 2 to 8 tends to increase the unit energy from 1.87 to 2.65 kW.h/Mg, at corn stalk moisture content of 65 % and cutter head speed of 22.1m/s. Chopping machine at number of knives 2 and moisture content 35 %, when the cutter head speed increased from 22.1 to 35.3 m/s tends to decreased the unit energy from 5.19 to 2.91 kW.h/Mg. Chopping machine at cutter head speed of 35.3 m/s and number of knives of 8, when the corn stalk moisture content increased from 35 to 65 % tends to decrease the unit energy from 3.10 to 1.65 kW.h/Mg. These results agreed with that obtained by Mohamed *et al.*,1999.

**6- Chopping machine cost ( L.E/Mg ) :-**

The chopping machine cost of stalk residues was estimated. It could be cleared that the chopping machine cost was found to be 25.48 L.E/h. The chopping machine cost was 16.33, 13.07, 9.63, and 7.22 L.E/Mg, when the cutter head speed increased from 22.1 to 35.3 m/s at corn stalks moisture content of 65 %and number of knives 8.

**Table 3: Effect number of knives and cutter head speed on unit energy at different moisture contents.**

Corn stalk moisture content, %	Cutter head speed, m/s	Unit energy, kW. h/Mg.		
		Number of knives		
		2	4	8
35	22.1	5.19	5.25	5.40
	25.6	4.60	4.59	4.96
	29.2	3.67	3.76	3.83
	35.3	2.91	3.03	3.10
45	22.1	2.41	2.66	2.72
	25.6	2.33	2.40	2.46
	29.2	2.25	2.32	2.40
	35.3	1.96	2.00	2.10
65	22.1	1.87	2.59	2.65
	25.6	1.66	1.74	1.89
	29.2	1.60	1.66	1.75
	35.3	1.37	1.46	1.65



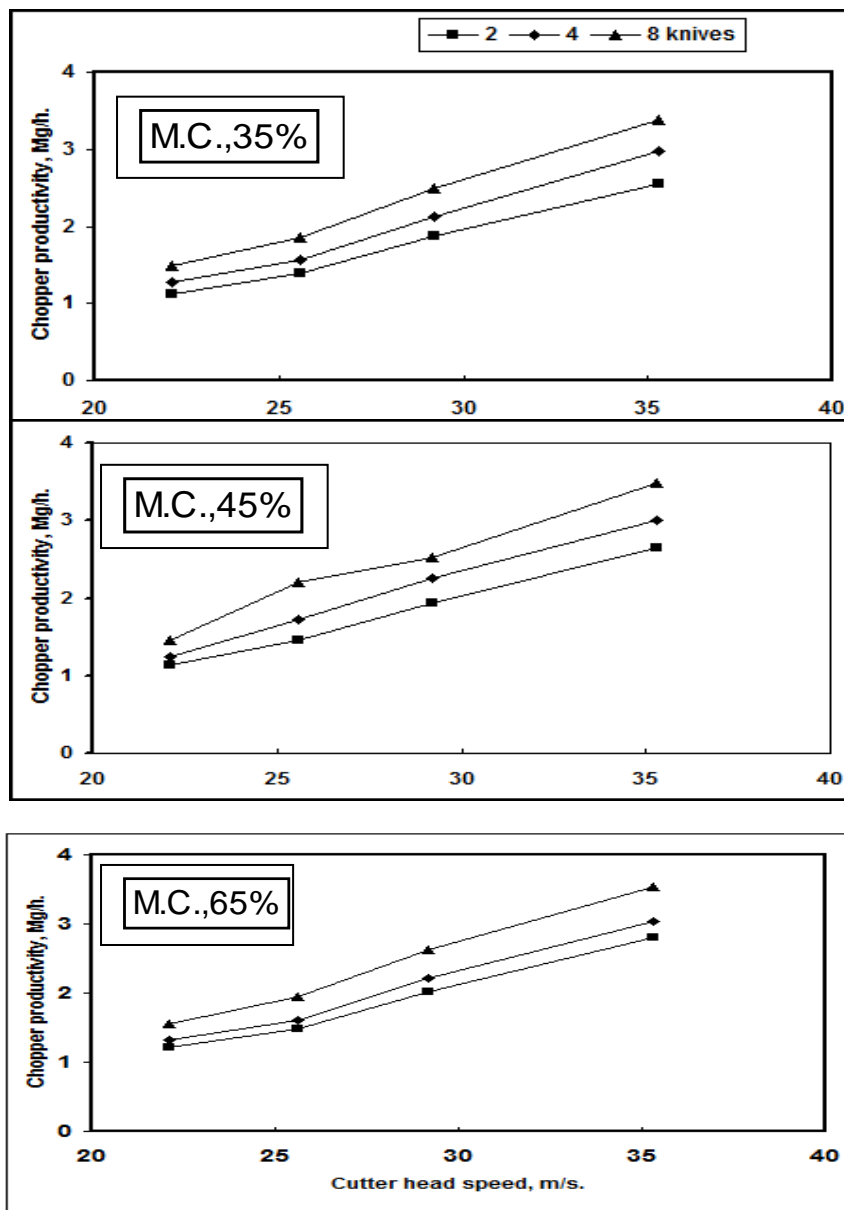


Fig.2:Effect of cutter head speed and number of Knives on chopper productivity at different moisture content.

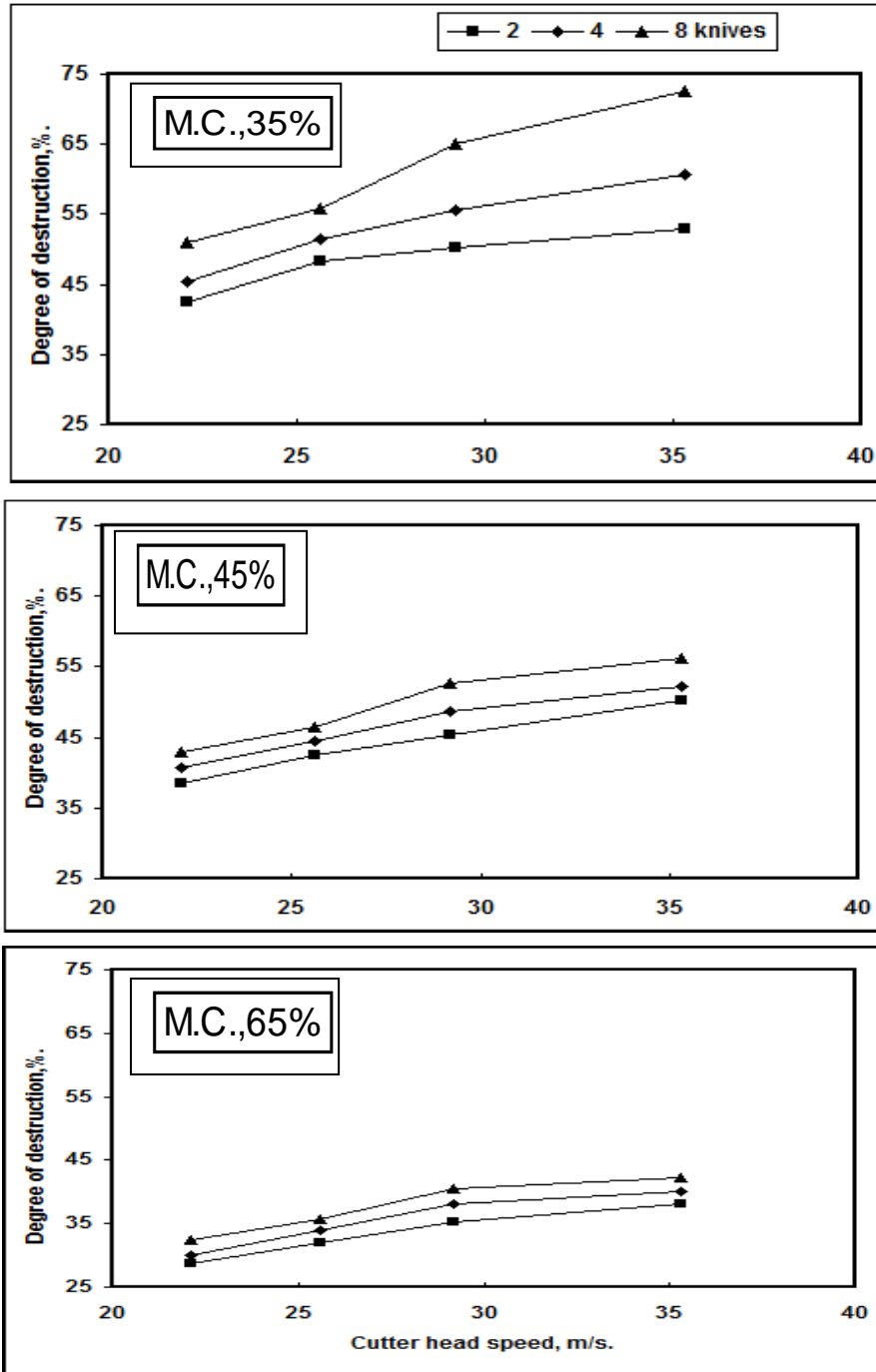


Fig. 3: Effect of cutter head speed and number of knives on degree of destruction at different moisture content.

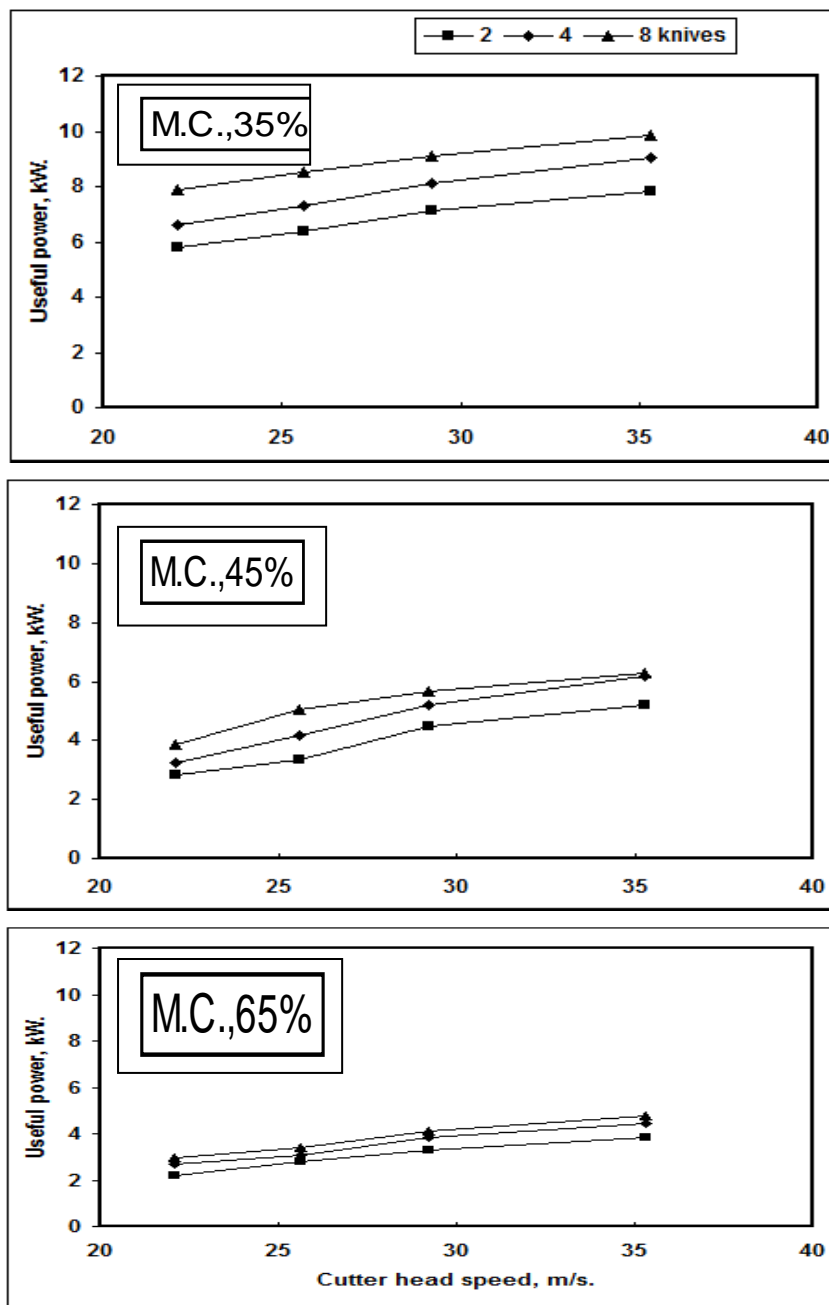


Fig. 4: Effect of cutter head speed and number of knives on useful power at different moisture content.

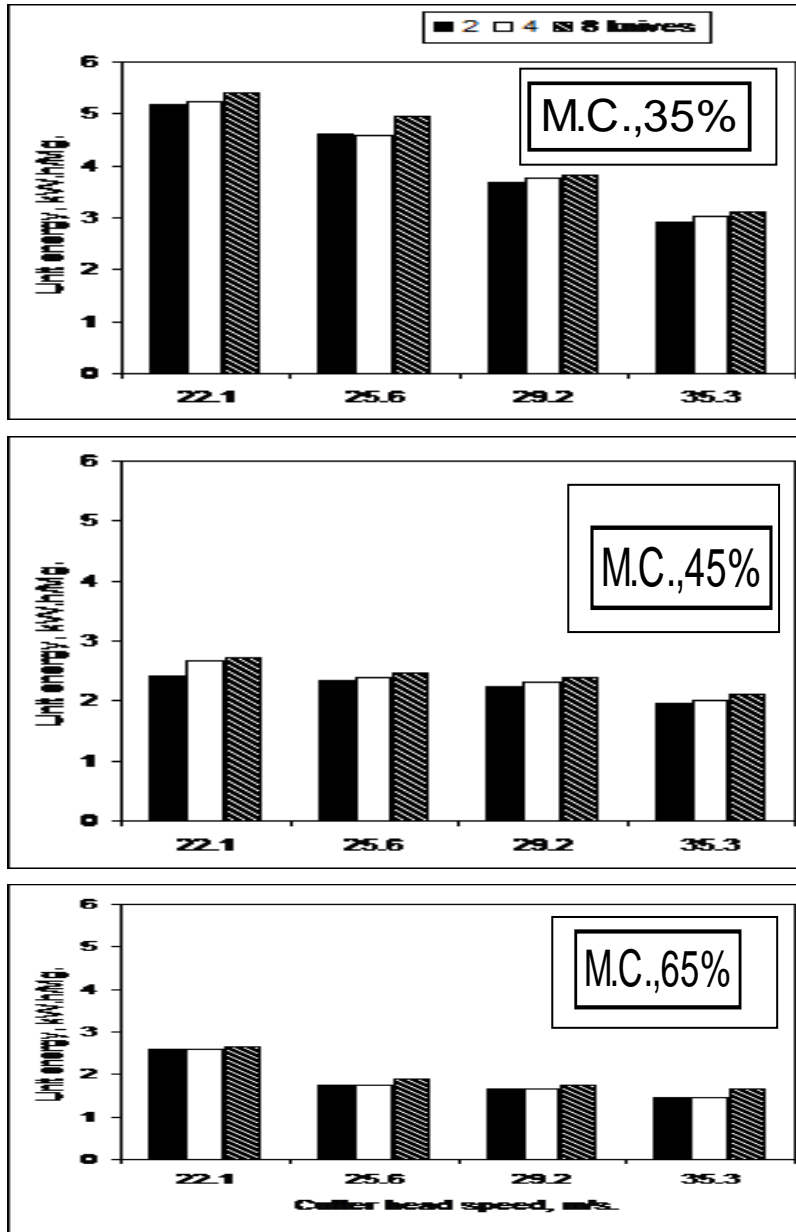


Fig. 5: Effect of cutter head speed and number of knives on unit energy at different moisture content.

## CONCLUSION

- 1- The chopper productivity values of 1.56, 1.95, 2.63 and 3.53 Mg/h were obtained when using 8 knives on chopper cutter head under cutter head speed of 22.1, 25.6, 29.2 and 35.3 m/s at corn stalks moisture content of 65.0 %
- 2- By increasing cutter head speed from 22.1, 25.6, 29.2 and 35.3 m/s tends to increase the degree of destruction from 50.9, 55.8, 65.1 and 72.5 %, respectively. At moisture content 35% and number of knives 8.
- 3- When the cutter head speed increased from 22.1 to 35.3 m/s and number of knives from 2 to 8 knives tends to increase useful power from 2.19 to 3.86 kW, 2.19 to 2.94 kW and decreased useful power from 5.81 to 2.19 kW by increasing corn stalks moisture content from 35 to 65 %, at number of knives 2, and cutter head speed of 22.1 m/s.
- 4- The unit energy in kW.h/Mg decreased from 5.19 to 2.91 kW.h/Mg and 1.87 to 1.37 kW.h/Mg when the cutter speed increased from 22.1 to 35.3 m/s and corn stalk moisture content increased from 35 to 65%. Also, by increasing number of knives from 2 to 8, tends to increase the unit energy from 1.87 to 2.65 kW.h/Mg, at moisture content of 65 % and cutter head speed of 22.1 m/s.
- 5- Total chopping machine cost was found to be 16.33, 13.07, 9.63 and 7.22 L.E/Mg, when the cutter head speed increased from 22.1, 25.6, 29.2 and 35.3 m/s, at corn stalks moisture content of 65 % and number of knives 8.

### Recommendations :-

Results of this study may be recommended, that silage production can be produced by chopping corn stalk at 65.0% moisture content with using 2 knives on cutter head and cutter head speed of 35.3 m/s. Meanwhile, at the same corn stalk moisture content and cutter head speed chopping corn stalk for direct feeding may be obtained by using 8 knives on cutter head to obtain an minimum energy consumption.

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### تأثير بعض العوامل التشغيل لآلة فرم المخلفات الحقلية على جودة فرم سيقان الذرة

محمود احمد العطار ، سمير خضر عبد العاطي و عبدا لحواد على سليمان  
معهد بحوث الهندسة الزراعية- مركز البحوث الزراعية-الدقي الجيزة

تعتبر المخلفات الزراعية احد المشاكل الحيوية التي تواجه المزارع المصري في الوقت الراهن في كيفية الاستفادة المباشرة منها أو إعادة تدويرها حيث يصل إجمالي المخلفات الزراعية إلى 18 و 25 مليون طن سنويا والتي يمكن أن تعتبر احد الموارد الطبيعية لزيادة الدخل القومي بما يقرب من 1 و 6 مليار جنية مصري سنويا

ولتحقيق هذا الهدف أجريت تجارب على آلة فرم المخلفات الحقلية محلية الصنع آلتيك لفرم حطب الاذرة في مركز ميكنة الأرز بميت الديبة موسم 2012 تحت تأثير المتغيرات الآتية:-

- 1- أربعة سرعات دوران نية لسكاكين الفرمة ( 1 و 2 و 25 و 29 و 3 و 35 م/ث ) 0
- 2- ثلاث أعداد لسكاكين الفرمة ( 2 – 4 – 8 ) 0
- 3- ثلاث محتويات لرطوبة عيدان الاذرة ( 35 – 45 – 65 % ) 0

وقد كانت النتائج المتحصل عليها كما يلي :-

- 1- أدى زيادة المحتوى الرطوبي لعيدان الاذرة من 35 إلى 65 % إلى نقص درجة تدمير ديدان ثاقبات الساق من 72و5 % إلى 42و3 %
- 2- عندما زادت سرعة سكاكين القطع من 22و1 إلى 35و3 م/ث وعدد السكاكين من 2 - 8 أدت إلى زيادة القدرة المستفادة من 2و19 إلى 3و86 كيلوات و 2و19 إلى 2و94 كيلوات ونقصت القدرة المستفادة من 5و81 إلى 2و91 كيلوات بزيادة المحتوى الرطوبي لعيدان الاذرة من 35 إلى 65 % عند ثبات عدد السكاكين 2 والسرعة الدورانية لسكاكين الفرم 22و1 م/ث
- 3- عندما زادت سرعة سكاكين الفرم من 22و1 إلى 35و3 م/ث و المحتوى الرطوبي من 35 إلى 65 % أدى إلى نقص وحدة الطاقة من 5و19 إلى 2و91 كيلوات/ساعة / ميغا جرام ومن 1و87 إلى 1و37 كيلوات/ساعة/ ميغا جرام على التوالي وبزيادة عدد السكاكين من 2 - 8 سكينه أدى إلى زيادة وحدة الطاقة من 1و87 إلى 2و65 كيلوات/ساعة /ميغا جرام عند محتوى رطوبي 65% وسرعة سكاكين القطع 22و1 م/ث
- 4- التكاليف الكلية لفرم حطب الاذرة كانت 16و33 - 13و07 - 9و63 - 7و22 جنية / طن عندما زادت سرعة سكاكين الفرم من 22و1 - 25و6 - 29و2 - 35و3 م/ث عند المحتوى الرطوبي 65 % وعدد سكاكين الفرم 08

ألتوصيات:-

توصى الدراسة عند عمل السيلاج يراعى تشغيل الإلآة عندما يصل المحتوى الرطوبي 65 % باستخدام 2 سكينه على درفيل القطع وسرعة سكاكين القطع 3و35 م/ث بينما يفضل تشغيل الإلآة باستخدام 8 سكينه على درفيل القطع عند فرم الاذرة بغرض التغذية المباشرة عند نفس المحتوى الرطوبي وسرعة سكاكين القطع وذلك لتقليل الطاقة المستهلكة في عملية الفرم

قام بتحكيم البحث

كلية الزراعة - جامعة المنصورة  
كلية الزراعة - جامعة الازهر

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أ.د / علاء الدين على المسيرى