

## **DEVELOPING A CHOPPER FOR VOLUME AND BIOMASS REDUCTION OF WATER HYACINTH**

**Abdrabo, A. F. A; M. I. Shouhy and A. B. El-Nagar.**  
Agric. Eng. Res. Inst. (ARC), Giza, Egypt

### **ABSTRACT**

A forage chopper machine was developed for compressing and chopping freshly collected water hyacinth in order to facilitate handling and transportation from water bodies to the utilization factories. The machine developments have been proposed as means of reducing volume and biomass or increasing density of the aquatic weeds that having large quantity of volume and moisture content. Whereas, the feeding mechanism of the chopper was modified and adapted for compressing process using three modified drums, controllable compressing loads, and a rough surface flat belt. The performance of the developed chopper was tested for volume and biomass reduction under three processing variables such as four feed rate levels (8, 12, 16, and 20kg/min), four applied compressing load levels (2, 3, 4, and 5kN), and four cutting knife speeds levels (3, 4.5, 6, and 7.5m/s). The developed chopper performance was evaluated *firstly* by determining changes in specific mass, volume, and chopping efficiency as affected by the processing variables. *Secondary* by determining machine productivity (ton/h), specific energy required (W.h/t) to operate the developed chopper and machinery unit cost (LE/ton). The obtained results revealed that the developed chopper reduced the specific volume and mass of fresh water hyacinth up to 74.6% and 26.3% at a feed rate of 20 and 8kg/min respectively, knife speed of 6m/s and applied compressing load of 5kN. To run the machine at the highest processing variable levels, maximum chopping efficiency of 80% and machine productivity of 0.97ton/h were achieved. The maximum power and specific energy were required to operate the chopper of 3.9kW and 12.5kW.h/t at a feed rate of 20 and 8kg/min, respectively and applied compressing load of 5kN with lower machine unit cost of about 9.5LE/ton.

### **INTRODUCTION**

Water hyacinth (WH) (*Eichhornia crassipes* Mart.) is the predominant, persistent and troublesome aquatic weed in the world and has posed ecological and economic problems in several countries. Utilization of WH is an important way of managing the weed problem and contributing to environmental management as well as creating employment and generating income for those who are most affected by it. As a readily available resource, WH has been used in several small cottage industries for paper, rope, basket, mats, shoes, sandals, bags, wallets, vases, etc. (Ndimele et al., 2011 and Patel, 2012). The WH is used to treat waste water from dairies, tanneries, sugar factories, pulp and paper industries, palm oil mills, distilleries, etc. WH also has been found to be rich in protein, vitamins and minerals and serves as a high quality feedstock for some non-ruminant animals, poultry and fishery in Indonesia, China, Philippines and Thailand (Lu et al., 2010). Many studies have been conducted to evaluate utilization of WH for such uses as phytoremediation, animal feed, as a fuel, handicrafts, furniture, biogas, compost, pollution abatement and paper pulp with limited

success. In these applications, one of the major problems is the high cost of transportation of freshly harvested WH from water bodies to the factories. Capacities of mechanical management systems for aquatic plants are usually limited by the volume of the plant material that must be handled, transported and stored (Innocent *et al.*, 2008). As fresh WH has around 92% moisture content with the bulk density of approximately  $96\text{kg/m}^3$ , it necessitates handling a plant volume of  $130\text{m}^3$  and disposing of 9.2ton of water for every ton of dry matter removed from the site. Compacting or squeezing is a type of size reduction that deals with the application of force to a unit being reduced in excess of WH moisture content(Mathur and Singh 2000).The literature reported that the energy consumptions of feedstock size reduction mainly depends on (i) machine parameters such as motor speed, material storage capacity of the mill chamber, as well as cutting mechanism such as knife, hammer, ball or disk mills; (ii) material throughput characteristics; (iii) initial biomass form and properties (e.g., moisture content, temperature, chemical composition, etc.); and (iv) particle size and shape requirement of the final product (Bitra *et al.*, 2009; Zhu *et al.*, 2009; Bridgeman *et al.*, 2010).Shailendra *et al.*, (2004) developed WH chopper with crusher to reduce volume and mass of freshly harvested WH to facilitate transportation. Two feed rate and knife speeds variables were studied to determine relationships between changes in specific volume, knife speeds; percent mass loss and feed rates. Mass reduction studies showed that increasing feed rate and knife speed resulted in a decrease in mass loss. Maximum mass loss of 34% was achieved with the minimum feed rate of 1t/h and a knife speed of 3.1m/s. Logistic components, technology, equipment and economic feasibility of feedstock delivery chains are highly subject to efficiency of biomass mechanical size reduction. Biomass mechanical size reduction, transportation and storage represent between 13% and 28% of the total feedstock production and supply costs (Cundiff and Grisso, 2008).

The aim of the present study was to reduce the problems of transportation of freshly harvestedwater hyacinth. Therefore the objectives of this study are devoted firstly to develop a forage chopper machine model (FC-18C) to be able for volume and mass reduction of WH within combination of compressing and chopping operations in a single machine. Secondary objective was to determine and evaluate the effects of three processing variables (feed rate, applied compressing load, and cutting knife speed) on changes in specific volume, mass, chopping efficiency and machine productivity (ton/h). Thirdly objective was to determine the specific energy (W.h/t), and machinery unit cost (LE/ ton) required to operate the developed chopper.

## **MATERIALS AND METHODS**

The present work was carried out during summer season 2013 at Rice mechanization center, Meet El-Deeba, Kafrelsheikh Governorate. To achieve the objectives of the present study two sequences stages were accomplished. The first stage was to develop a forage chopper model (FC-18C) to be able for optimal volume and mass reduction of freshly collected water hyacinth. While the second stage was to carry out the experimental work that aimed to determine and evaluate the effects of the processing variables on the developed chopper performance. Preliminary tests were conducted on the original chopper before development to decide the rational modifications required for the investigated chopper. However a lot of accumulation and clogging problems were observed during carried out the preliminary tests. These problems were attributed to the low density, and the high moisture contents of freshly water hyacinth. Based on this preliminary study it was proposed to combine both compressing and chopping operations in a single machine. Hence the feeding mechanism of the original chopper was developed as means of reducing volume and mass as well as increasing density of the feeding WH samples. The developing stage excluded three modified drums, controllable compressing loads, and a rough surface flat belt.

### **Materials:**

#### **Water hyacinth:**

The fresh water hyacinth was collected from an irrigation canal near the RMC, Meet El-Deeba, Kafrelsheikh governorate. The initial moisture content of WH samples was determined using the hot air oven at 130°C for 24h, AOAC (2005). It was around  $91.5 \pm 1$ , %, w.b, during the experiments. The average mass and height of fresh WH plants was 0.45kg and 400mm, respectively. The roots of the plant were cut off and the stem and leaves of the plant was acquired, only. Material was packed loosely and its initial specific volume and mass were determined. The relationship between the mass per kg and the volume per cubic meter of the fresh WH before chopping was of about  $120 \text{kg/m}^3$ .

#### **The developed forage chopper machine:**

The main specifications of the forage chopper under investigation are presented in Table 1. It consists of the feeding mechanism to compress and hold the materials, and the chopping unit to chop the materials to small lengths.

**Table 1. The technical specification of a Star forage chopper machine.**

Specification	Value
<b>Main dimensions:</b>	
Total length, mm	1700
Total width, mm	1100
Total height, mm	2200
Total mass, kg	320
Number of cutting drums	2
Source of power	Diesel engine (5kW)
Model	FC-18C

The technical specifications of the machine parts used for compressing and chopping of WH to reduce the size and mass are summarized in the following steps.

**Developed feeding mechanism system for WH:**

The feeding mechanism was modified using three drums and rough flat surface belt to compress the materials before feeding to chopping or cutting unit. The compressor was fixed on feeding drums with free roller drums supported on an axle by means of 2 rollers bearings as shown in Fig. 1. The drum was scraped on its surface in a helical form to push the materials in feeding direction. Two springs were used to control the compressing ratio of the feed material by change the position of the lever link of the drums (gate opening control) or change the spring itself, depending on the feed material type. Also, the feed material is pressed by using double stages of feeding drums.

**Flat belt to drag and compressed WH:**

Elevation, side and plane views of the developed feeding mechanism of forage chopper machine are shown in Fig. 1. The developed rough surface flat belt is shown in Fig. 2 and 3 and Plate 1. The feeding mechanism was modified using three drums. The first drum has 30mm length and 70mm diameter, the second drum has 25mm length and 90mm diameter, while the third drum has 20mm length and the same diameter as the first drum (70mm). The second (medium) drum has larger diameter (90mm) than the others to keep the belt in contact with the materials without slippage by help the conveyer trough. The first drum has gap entrance bigger than the second, the third one has also compact ratio more than the second. Thus the movement of feed case smoothing to arrive to the suitable compaction ratio of the material and could obtain uniform feeding. The modified feeding system keeps a regular feeding flow of the raw material and compressed it to increase the cutting efficiency, have a high pressure and make high bulk density ( $\text{kg/m}^3$ ) for the feeding material through the opening gate. Consequently, the capacity of the developed machine (ton/h) becomes more throw the same gate opening and safety performance. The chopped materials are bellowed through a rectangular thrower outlet (30x25cm) as a result of the rotation of the cutter head system.

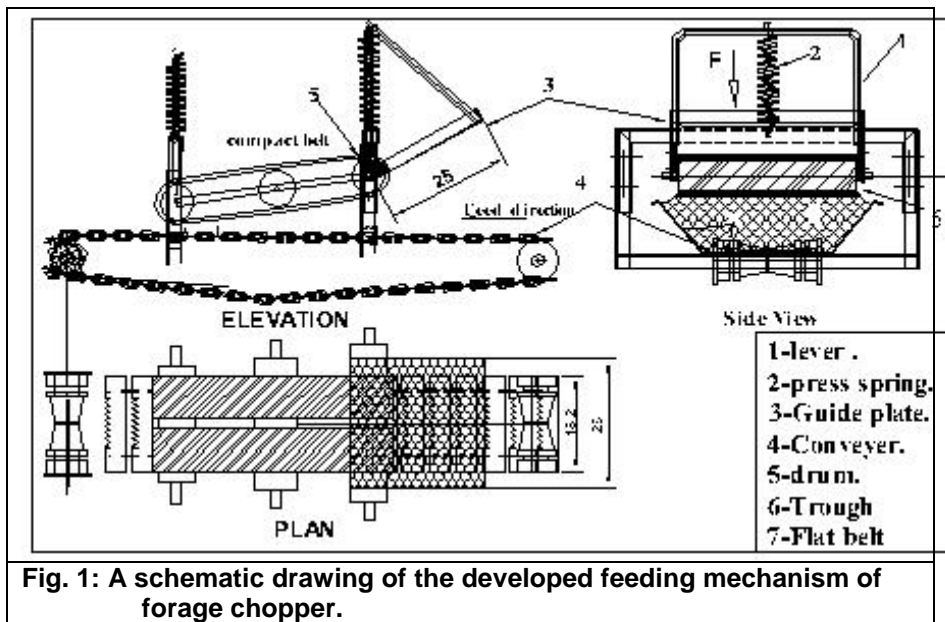
**The cutter head systems:**

The cutter head flywheel system consists of 2 knives (flat and logarithmic curve edge) fixed on arms of the flywheel make  $180^\circ$  each other,

rotates in clockwise direction by the flywheel, and one fixed knife (flat and straight edge) fitted at 4cm down the level of the flywheel.

**Power supply:**

A diesel engine developing 5kW was chosen to drive the various components of the machine. That engine was replaced instead of the electric motor of the forage chopper machine in order to avoid the problems associated with electrical power connection at high moisture contents of the investigated collected water hyacinth. The diesel engine was fixed on special chaise that equipped with the main machine frame as shown in Plate 3. Two variable diameters pulley and V-belts drive transmission system was equipped between the engine axis and the main machine axis. That system was used to transmit the engine power to cutter head flywheel and feeding mechanisms.



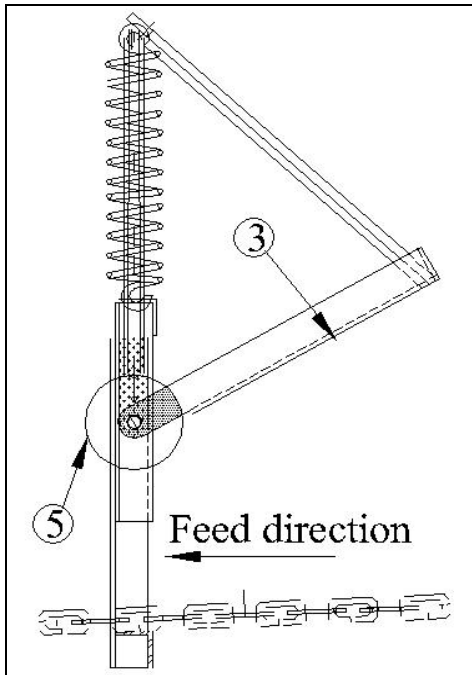


Fig. 2:Free feeding drum

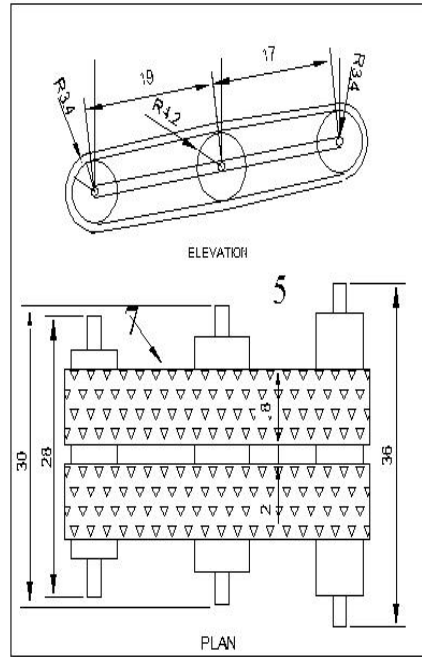


Fig. 3:Elevation and plane of drums and the rough surface flat belt.



Plate 1: Developed compressor and the flat belt



Plate 2: Diesel engine equipped with pulleys

**Methods:**

The experiments were conducted at four feed rating (8, 12, 16 and 20kg/min), four pressure or compressing force (2, 3, 4 and 5kN) and four cutting knife speed (3, 4.5, 6 and 7.5m/s) to study their effect on the specific mass and volume losses, % of WH as well as the performance of developed chopper. The cutting knife speed was changed by changing gear diameters and measured by using Tachometer. The desired knife speed was achieved by adjusting the speed reduction unit. The speed ratio between cutting knife and feeding mechanism which regulate the feeding rates was adjusted at (20:1) as recommended by Marey *et al.*, (2007) for chopping sugar cane bagasse. The sized and massed samples were put into the machine to compressing and chopping at specific time at different operating parameters. The material coming out of the machine was collected in a container placed just below the outlet gate and its volume and mass were again determined. The compressing force on the feeding mechanism was evaluated for the helical compression springs used as the following (Blak and Adams, 2000):

Where:

k= coefficient of spring stiffness, N/m and

s= the deflection distance of spring, m.

Performance of the developed machine was evaluated on the basis of volume and mass reduction of freshly collected WH, cutting efficiency, machine productivity, power consumption, energy requirement and costs as follows.

**Specific mass losses:** The percentages of specific mass losses were determined using the following relationship:

Where:

M<sub>1</sub>= Mass of WH before chopping, kg.

M<sub>2</sub>= Mass of WH after chopping, kg.

**Specific volume losses:** The percentages of specific volume losses were determined using the following relationship:

Where:

$V_1$ = Volume of WH before chopping,  $m^3$ .

$V_2$ = Volume of WH after chopping,  $m^3$ .

**Cutting efficiency, %:**

The cutting length of final product is an important parameter to evaluate the performance of chopping process. Where, the suitable length that can be used to produce the compost and the forage is in the range of  $0 < L_C < 50mm$ . There are standard sieves used for segregation of a specific mass,  $S_b$ , from the chopped production to several masses, having cutting length  $0 < L_C < 50mm$ . Consequently, the cutting efficiency can be calculated as following(Soliman *et al.*, 2010):

Where:  $S_b$  is the mass of the chopped WH before segregation, g and  $S_a$  is the mass of the

chopped WH after segregation of cutting length  $0 < L_C < 50mm$ , g.

**Machine productivity, ton/h:**

The running time of the experiment was measured by a stop watch. The machine productivity was calculated by dividing the compressing and chopping mass with the required time of compressing and chopping (ton/h).

**Power consumption, kW:**

The fuel consumption was measured using special device consist of 3 liter graduated cylinder which is connected to fuel pump. The reduction of fuel in tube after executing each treatment was recorded. The total power requirements consumption for modified chopping machine was calculated according the principles and assumption of Hunt (1995):

$$EP = \frac{FC \times \rho_f \times L.C.V \times 427 \times \eta_m \times \eta_{th}}{3600 \times 75 \times 1.36}, kW \dots\dots\dots$$

.....(5)

Where:

- EP= Power requirements consumption during chopper operation, kW;
- FC= Fuel consumption, L/h;  $\rho_f$ = Density of the fuel, 0.85 kg/Lfor solar fuel;
- L.C.V = Lower calorific value of fuel, 10000 kcal/kg, for solar fuel;
- 427 = Thermo mechanical equivalent, kg. m/kcal;
- $\eta_m$  = Mechanical efficiency of engine, 80% for diesel engine, and
- $\eta_{th}$ =Thermal efficiency of the engine, (considered to be about 40% for diesel engine).

The energy requirements in (kW. h/ton) was determined by calculating the consumed power, kW then divided by the machine productivity, ton/h:

**Energy requirements, kW. h/ton =Consumed power/Machine productivity ---(6)**

**Cost estimation:**



The costs of the modified chopping machine for WH were estimated according to **Awady et al., (2003)** using the following equation:

$$C = p/h (i/y + i/2 + t + r) + (0.9 W. S. F) + m/144 \text{ (LE/h)} \dots \dots \dots (7)$$

Where:

- C = Hourly cast (LE/h);
- P = Price of machine (5000LE, 2010 prices level, 1USA dollar =6.0LE);
- h = Yearly operating hours (1000h/ yr.); y = Life-expectancy of tractor (10yr.);
- i= Interest rate (10%/yr.); t = Taxes and overhead ratios (5%/yr.);
- r =Repairs and maintenance ratio (10%/ yr.); 0.9= A factor accounting for lubrication; W= Power (5kW); S= Specific of fuel consumption (0.25L/kW h);
- F= Fuel price (1.25LE/L); m = Operator monthly salary (600LE/mo.) and
- 144 = Monthly average hours (h/mo.).

**Operating costs, LE/ton= machine hourly cost, LE/machine capacity, Ton/ h..(8)**

**Criterion function cost, LE/ton= operating cost, LE/ton+losses cost, LE/ton.(9)**

## RESULTS AND DISCUSSIONS

### Reduction of specific mass, %:

The observations indicated in Fig. 4 shows the effect of feed rate and cutting knife speed on reduction of specific mass at various tested pressure forces. The data reveal that the percentage of specific mass losses increase by increasing the knife speed from 3 to 6m/s, while, it was decreased with increasing the knife speed to 7.5m/s. However, increasing pressure force from 2 to 5kN tends to increase the percentage of mass losses from 21.3 to 26.3% at feeding rate of 8kg/min and knife speed of 6m/s. While increasing feed rate from 8 to 20kg/min tends to decrease the percentage of mass losses from 26.3 to 18.5%, at pressure force of 5kN and knife speed of 6m/s. The maximum percentage of mass losses of 26.3% was recorded at knife speed of 6m/s, pressure force of 5.0kN and feed rate of 8kg/min. The decrease in mass losses with increasing feed rates could be attributed to the applied pressure force was not enough to compact the large quantity of materials passing through the same feed gate area. However, the minimum percentage of mass losses of 10.3% was recorded at knife speed of 3m/s, pressure force of 2kN and feed rates of 20kg/min. The slight decrease in mass losses with higher feeding rate more than 16kg/min may be due to the fact that increased feed rates beyond this, the material thickness between the rollers and belt increased and the tissue reabsorbs the moisture released after compressing process. This result is agreed with the results obtained by Shailendra *et al.*, (2004).



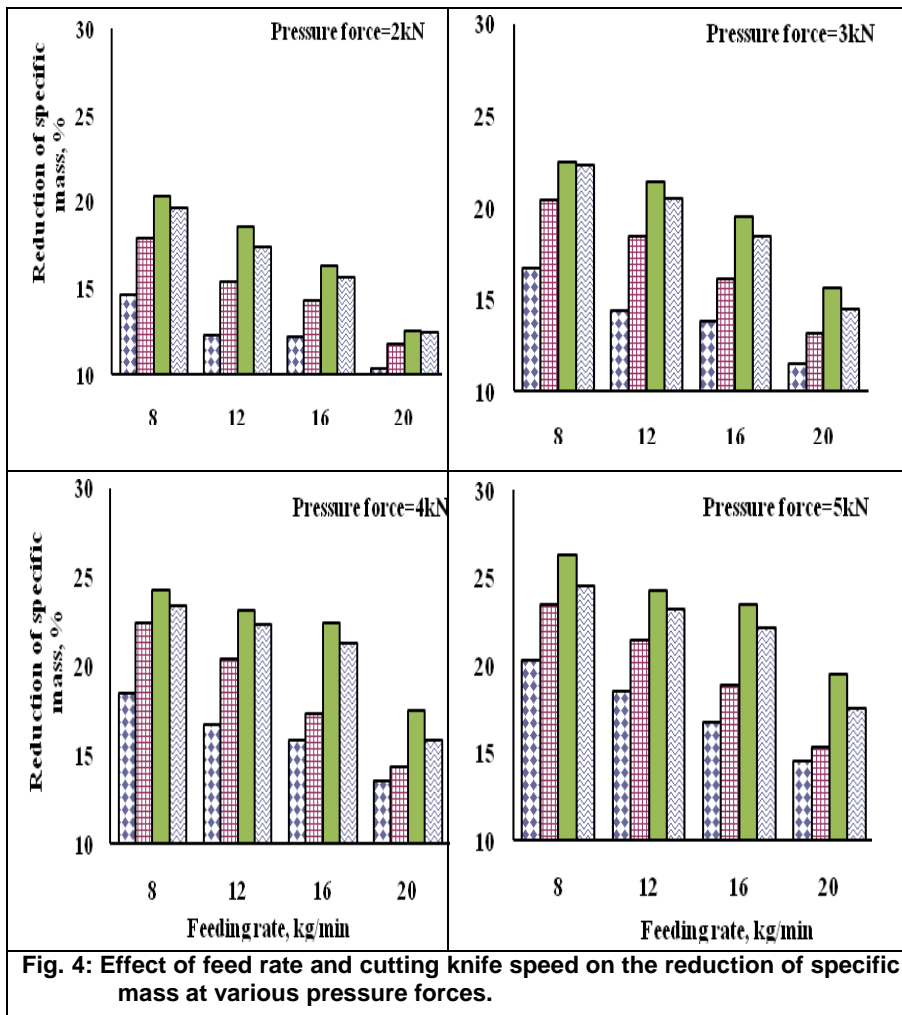
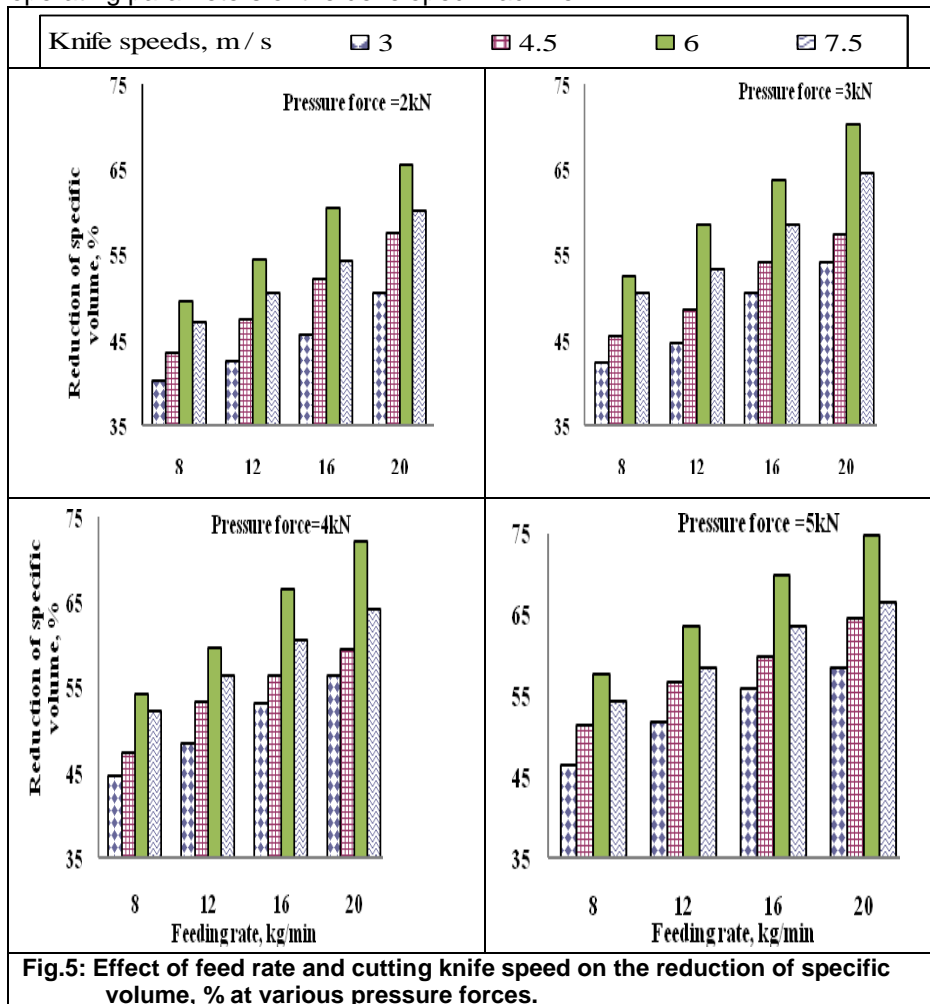


Fig. 4: Effect of feed rate and cutting knife speed on the reduction of specific mass at various pressure forces.

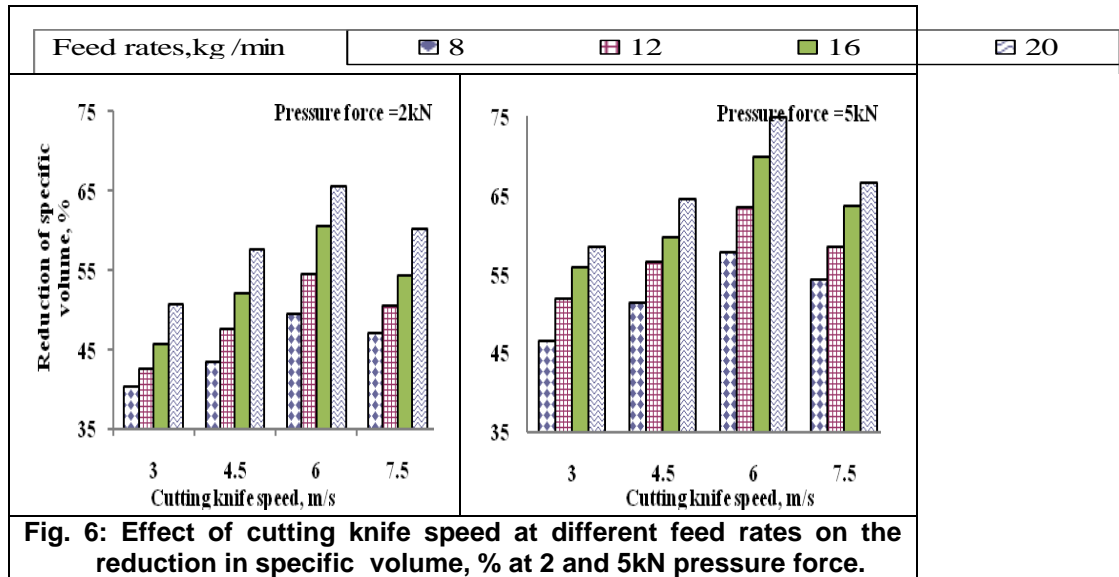
**Reduction of specific volume, %:**

The effect of feed rate and cutting knife speed on the reduction of WH specific volume at various pressure forces was studied and the results as presented in Fig. 5. It was found that increasing the feed rate from 8 to 20kg/min tends to increase the percentage of volume losses from 57.7 to 74.8% at knife speed of 6m/s and pressure force of 5kN. However, increasing pressure force from 2 to 5kN tends to increase the percentage of volume losses from 49.5 to 57.7% at knife speed of 6m/s and feed rate of 8kg/min. The maximum percentage of volume losses of 74.8% was recorded at knife speed of 6m/s, pressure force of 5kN and feed rates of 20kg/min. While, the decreases in volume losses with higher knife speed, at speeds higher than 6m/s, may be attributed to lower density of compressed materials and lesser contact time between rollers and compressed materials in contact area, thus reduced compressing and crushing forces as shown in Fig. 6. Also, the

increase of volume losses with higher feeding rate (20kg/min) may be due to the fact that at higher feed rates, the material thickness between the rollers and contact area increased which resulted in more compressing and crushing and thereby reducing the specific volume. However, the minimum percentage of volume losses of 42.3% was recorded at knife speed of 3m/s, pressure force of 2kN and feed rates of 8kg/min. This result was agreed with the results obtained by Shailendra *et al.*, (2004). It can be seen that the volume reduction rate was higher than the reduction rate of biomass with all studied operating parameters of the developed machine.



**Fig.5: Effect of feed rate and cutting knife speed on the reduction of specific volume, % at various pressure forces.**



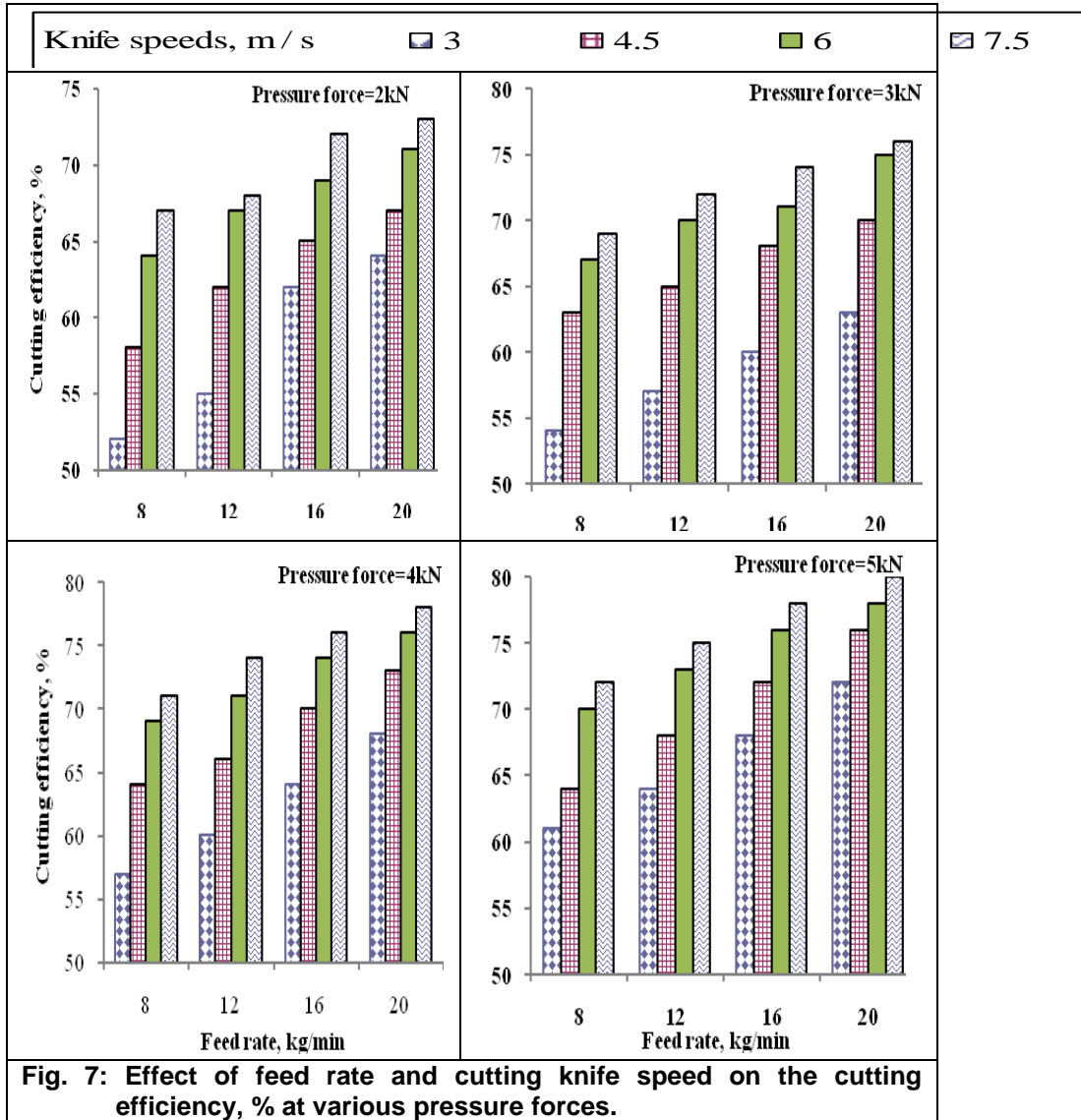
**Cutting efficiency, %:**

The fineness of final production is an important parameter to evaluate chopper performance. The cutting length suitable to produce compost and animal organic is  $L_c \leq 50$  mm, (Soliman *et al.*, 2010). The effect of feed rate and cutting knife speed on the cutting efficiency at various pressure forces was illustrated in Fig. 7. The general trend is that increasing feed rate and cutting knife speed leads to increasing cutting efficiency at various pressure forces. This may be due to the increase in the number of cuts per unit time which increase the mass of the suitable cutting length. While, the increase of cutting efficiency with increasing feed rate and knife speed was more effective than the increases in pressure forces. Also, the increase in cutting knife speed from 6 to 7.5m/s leads to little increase in cutting efficiency. The maximum cutting efficiency (80%) was obtained at feed rate 20kg/min and knife speed 7.5m/s and pressure force 5kN. While, the minimum cutting efficiency (52%) was obtained at 8kg/min feeding rate, 3m/s knife speed and 2kN pressure force. The decreasing cutting efficiency at lower feed rate may be due to some plant pass parallel to the cutting knife being not the right position and it pass without cut which decreases the cutting efficiency. This is in agreeing with the results reported Soliman *et al.*, (2010).

**Machine capacity, ton/h:**

Data illustrated in Fig. 8 shows the effect of feed rate and pressure force (at constant cutting knife speed of 6m/s) on the developed machine capacity for compressed WH as compared to fresh samples. It was noticed that increasing feed rate tends to increase the machine capacity, while it decreased with increasing pressure force. The maximum quantity of chopping fresh WH (1.2ton/h) and this mass has been reduced to 0.97ton/h after compressing and chopping by developed machine (20% reduction rate) at feed rate of 20kg/min, pressure force of 5kN and cutting knife of 6m/s. This

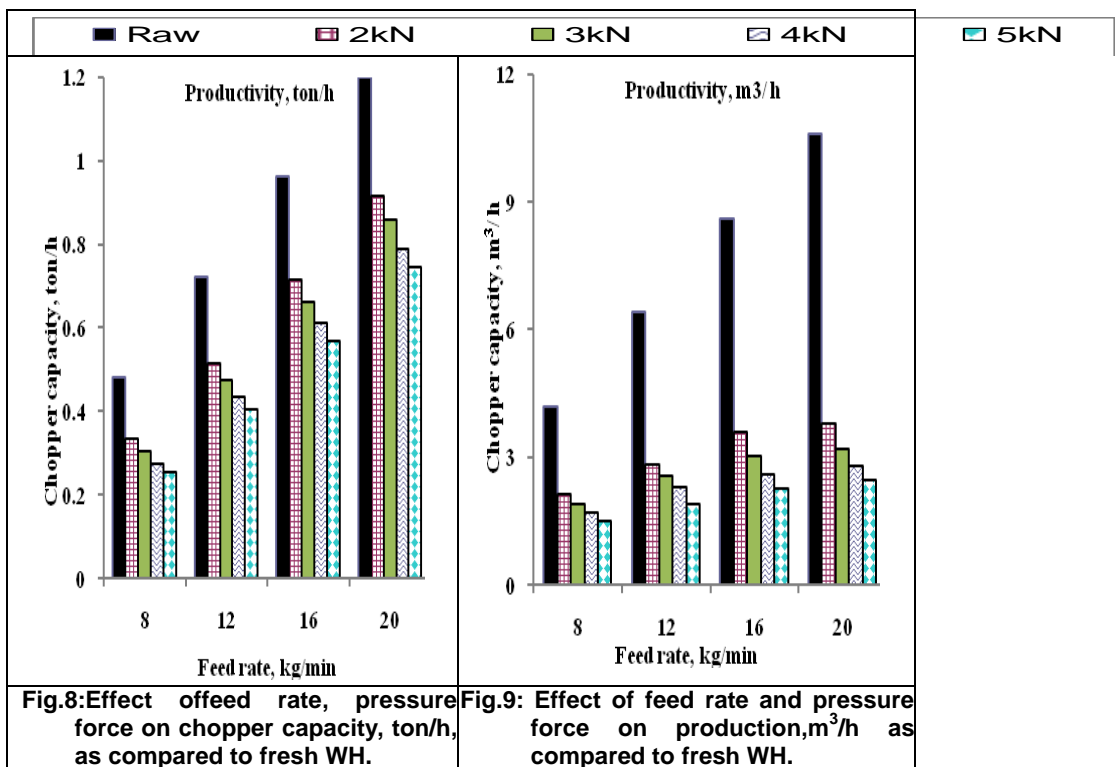
increase in machine capacity with the increase of feed rate may be due to the increase of compressed WH quantities which passed through the feeding unit at the same time before chopping, Chevanan *et al.*, (2010). While, the minimum quantity of chopping fresh WH (0.48ton/h) and this mass has been reduce to 0.354ton/h after compressing and chopping (26.3% reduction rate) at feed rate of 8kg/min, pressure force of 5kN and knife speed 6m/s.



**Fig. 7: Effect of feed rate and cutting knife speed on the cutting efficiency, % at various pressure forces.**

**Machine capacity, m<sup>3</sup>/h:**

Data illustrated in Fig. 9 shows the effect of feed rate and pressure force (at constant cutting knife speed of 6m/s) on production volume after compressing and chopping of WH as compared to fresh samples. It was found that increasing feed rate tends to increase the production volume, while, it was decreased with increasing pressure forces. The maximum quantity of freshly WH (10.4m<sup>3</sup>/h) before compressing and this volume has been reduced to 2.42m<sup>3</sup>/h after compressing (76.7% reduction rate) by developing machine at feed rate of 20kg/min, knife speed of 6m/s and pressure force of 5kN. While, the minimum production volume of freshly WH (4.2m<sup>3</sup>/h) before compressed and this volume has been reduced to 1.5m<sup>3</sup>/h after compressing (64.3% reduction rate) at feed rate of 8kg/min, knife speed of 6m/s and pressure force of 5kN. The relative size of the WH after compressing was 1: 4.24 as compared to freshly WH before processing which reduced transportation costs by more than 75% after compressing and chopping process by developed machine.

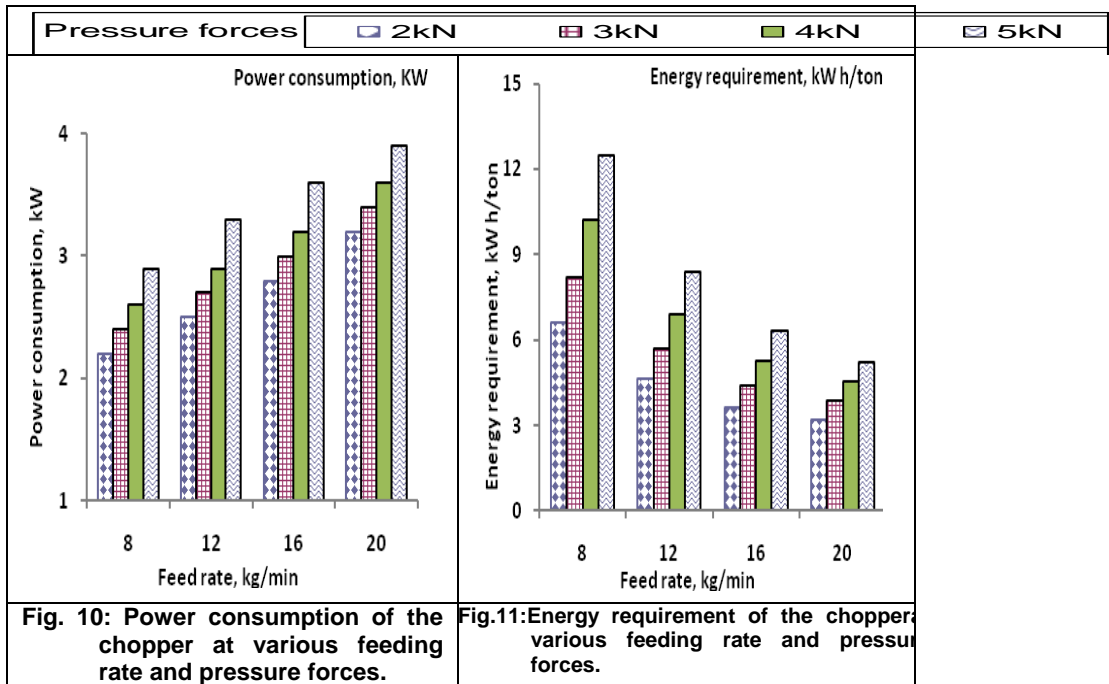


**Power consumption and specific energy requirements:**

The influence of feed rate as well as pressure force at constant cutting knife speed of 6m/s on the power consumption and specific energy requirement are presented in Fig. 10 and 11. Generally, increasing feeding rate and pressure force, at constant cutting knife speed of about 6m/s, tends

to increase the power consumption, while, the energy requirements was decreased. The maximum value of power consumption of 3.9kW was obtained using 20kg/min feeding rate at pressure force of 5kN. However, minimum value of power consumption of 2.2kW was obtained using 8kg/min feeding rate at pressure force of 2kN. It can be seen that increasing feeding rate from 8 to 20kg/min tends to increase the power consumption in average by about 39.6%.

While, increasing pressure force from 2 to 5kN tends to increase power consumption in average by about 27.7%. Whoever, the maximum energy requirement of 12.5kW.h/ton was obtained using 8kg/min feeding rate at pressure force of 5kN. However, minimum energy requirement of 3.17kW.h/ton was obtained at 20kg/min feeding rate at pressure force of 2kN. The increase in feed rate from 8 to 20kg/min tends to decreases the energy requirement in average by about 55.24%. While, increasing pressure force from 2 to 5kN tends to increase energy requirement in average by about 85.6%. The increase in energy requirements by increasing pressure force could be due to the higher increase in power consumption and at the same time the slower increase in production rate as well as due to more torque required rotating the machine with high compressed materials, Chevanan *et al.*, (2010). Meanwhile, the decrease of energy requirements by increasing feeding rates at the same pressure force may be due to the increase of the production rate in the same time.



**Operation and criterion functions costs of developed machine:**

The operation costs (LE/ton) of the developed chopper was calculated during compressing and chopping WH under 6m/s cutting knife speed and 5kN pressure force when increasing feed rate from 8 to 20kg/min. The maximum obtained operation cost was 9.5LE/ton for freshly WH at 20kg/min feed rate. The criterion function costs of the developed machine at four feed rates at constant pressure force of 5kN and cylinder speed of 6m/s was calculated as summarized in Table 2. The result revealed that the criterion function cost was decreased from 18.36 to 9.38LE/t when the feed rate increased from 8 to 20kg/min (by decreasing ratio of 48.9%). It can be seen that using higher feed rate and pressure force levels as well as cutting knife speed at 6m/s for compressing and chopping WH was suitable more than using the lower levels. This is due to the cost of the increment of energy per ton with increasing pressure forces and feed rate at 6m/s cutting knife speed not comparable at all with an increase of compressing and cutting efficiency of the developed machine.

**Table 2: Criterion function cost of the developed machine**

<b>Feed rates, kg/min</b>	<b>Total cost, LE/ton</b>	<b>Capacity, ton/h</b>	<b>Machine unit cost, LE/ton</b>	<b>Losses costs, LE/ton</b>	<b>Criterion function cost, LE/ton</b>
8	6.5	0.354	18.36	0.0	18.36
12	7.1	0.545	13.03	0.0	13.03
16	8.6	0.737	11.67	0.0	11.67
20	9.5	0.966	9.38	0.0	9.38

**Conclusion**

**The main results of the present study can be summarized in the following points:**

1. The maximum percentage of mass losses of 26.3% was recorded at cutting knife speed of 6m/s, pressure force of 5kN and feed rate of 8kg/min. While, the highest value of the volume losses, 74.8% were recorded at feed rate of 20kg/min.
2. The maximum machine capacity of freshly WH quantity of about 1.2ton/h, which reduce to 0.97ton/h (20%) , while, the maximum capacity of freshly WH volume of about 10.4m<sup>3</sup>/h, which reduce to 2.45m<sup>3</sup>/h (76.4%) at feed rate of 20kg/min, knife speed of 6m/s, and pressure force of 5kN.
3. Increasing feeding rate and pressure force tends to increases the power consumption in average by 39.6 and 27.7%, respectively. Whoever, specific energy requirement increased by about 85.56% by increasing pressure force, whiles it was decreased by about 55.24% by increasing the feed rate.
4. The highest cutting efficiency (80%) was obtained at higher levels of feed rate, cutting knife speed and pressure force.
5. The optimum output capacity of the developed machine was found to be 0.97ton/h obtained at 6m/s knife speed, 20kg/min feed rate and 5kN pressure force with operation cost of about 9.5LE/ton. While, the criterion



function cost was decreased by decreasing ratio of 48.9% when the feed rate increased from 8 to 20 kg/min.

6. The relative size reduction of the WH after compressing and chopping process was 1: 4.24 as compared to row sample, which reduced transportation costs of the total production by more than 75%.

## REFERENCES

- AOAC (2005). Official Methods of Analysis (18th Edn.) Association of Official Analytical Chemists. International, Maryland, USA.
- Awady, M. N.; I. Yehia, M. T. Ebaid and E. M. Arif (2003). Development and theory of cleaner for reduced impurities and losses. *Misr J. Ag. Eng.*, 20(4): 35-68.
- Bitra, V.S.P.; r. A. Womac; N. Chevanan; P. I. Miu; C. Ighathinathane; S. Sokhansanj and D.R. Smith, (2009). Direct mechanical energy measures of hammer mill comminution of switchgrass, wheat straw, and corn stover and analysis of their particle-size distributions. *Powder Technol.* 193: 32–45.
- Blak, P. H. and O. E. Adams (2000). Springs. In: *Machine design*. pp:209. John Wiley&Sons, Inc., New York, USA.
- Chevanan N.; K. A. Rosentrater and K. Muthukumarappan (2010). Effects of processing conditions on single screw extrusion of feed ingredients containing DDGS. *Food Bioprocess Technology*, 3:111–120.
- Chunkao, K.; C. Nimpee and A. Duangmal (2012). The King's initiatives using water hyacinth to remove heavy metals and plant nutrients from wastewater through BuengMakkasan in Bangkok, Thailand. *Ecological Engineering* 39: 40–52.
- Cundiff, J.S. and R.D. Grisso (2008). Containerized handling to minimize hauling cost of herbaceous biomass. *Biomass Bioenergy*, 3: 308–313.
- Hunt, D. (1995). *Farm power and machinery management*. Ames, Iowa: Iowa State Univ. Press.
- Innocent C.O.; O. G. Lawrence and A. N. Gitau (2008). Dewatering and Drying Characteristics of WH (*EichhorniaCrassipes*) Petiole. Part II. Drying characteristics. *Agricultural Engineering International: the CIGR E j. Manuscript FP 07033*. Vol. X.:1-11.
- Lu, J.; L. Zhu; G. Hu and J. Wu (2010). Integrating animal manure-based bioenergy production with invasive species control: A case study at Tongren pig farm in China. *Biomass Bio-energy*. 34: 821–827. doi:10.1016/j.biombioe.2010.01.026.
- Marey, S.A.; A. M. Drees and I. Syed Ahmed and A. A. El-Keway(2007). Development a feeding Mechanism of Chopper for Chopping Sugarcane Bagasse. *Misr J. Ag. Eng.*, 24(2):299-319.
- Mathur, S. M. (2000). Study on volume and mass reduction of WH. Ph.D. Thesis, Department of Farm Machinery and Power Engineering, College of Technology and Engineering, Udaipur-313 001, India.

- Mathur, S. M. and P. Singh (2000). Relationship in compression Pressure-density of WH. J. of the Institution of Eng., 81:49-51.
- Ndimele, P. and A. Jimoh (2011). WH (EichhorniacrassipesSolms.) in Phytoremediation of heavy Metal Polluted Water of Olga lagoon, Lagos, Nigeria. Research journal of Environmental Sciences, 5(5): 424-433.
- Patel, S. (2012). Threats, management and envisaged utilizations of aquatic weed Eichhorniacrassipes: Rev Environ Sci. Biotechnol,11:249–259.
- Shailendra M. Mathur and P. Singh (2004).A Cylindrical Chopper with Crusher for WH Volume and Biomass Reduction. J. Aquatic. Plan Manage., 42: 95-99.
- Soliman, A. E.; G. M. Nasr; M. A. Baiomy and A. R. Eid (2010). Study of some engineering factors concerning the performance of the affecting tool in crop residuals shredder. The 17<sup>th</sup> Conference of the Misr Society of Ag. Eng., 28 October, 27(4): 1555-1571.
- Zhu, J.Y.; G.S. Wang; X.J. Pan; R. Gleisner (2009). Specific surface to evaluate the efficiencies of milling and pretreatment of wood for enzymatic scarification. Chem. Eng. Sci., 64: 474–485.

### تطوير آلة فرم أعلاف لخفض حجم وكتلة ياسنت الماء عادل فتحي عبده عبدربه ، محمد إسماعيل شوغى و على بدوى النجار معهد بحوث الهندسة الزراعية - الدقي - الجيزة - مصر

يعتبر ياسنت الماء (ورد النيل) من أكثر الحشائش التي تسبب مشاكل في المجارى المائية في مصر والعالم. والمشكلة الكبرى تتمثل في تكلفة التخلص منه من الترع والمصارف بغرض تطهيرها وكذلك تكلفة النقل الكبيرة لهذا المنتج كنبات أخضر من مكان تجميعه إلى مكان تصنيعه بغرض الاستفادة منه في عديد من الأغراض كسماد عضوي أو مصنع كغذاء للحيوانات والإنسان حيث تحتوى أوراقه علي نسبة عالية من البروتين وفيتامين أ ويستخدم في صناعة الورق والشنط والأثاث والخشب وطوب البناء وإنتاج الايثانول والبيوايثانول والوقود الحيوي. وارتفاع نسبة الرطوبة به إلي 92% تقريبا وزيادة حجمه وانخفاض كثافته (120 كجم م<sup>3</sup>) تسبب مشكلة كبيرة عند المقاومة الميكانيكية له حيث تقل كفاءة الآلات وتزيد من تكلفة النقل والتداول. لذلك يلزم تجفيفه أو كبسه وتقطيعه وخفض كتلته وحجمه (زيادة كثافته) بغرض زيادة كفاءة عمليات النقل والتداول بالإضافة إلي منع تلوث البيئة. ولذلك تم تطوير آلة لفرم الأعلاف الخضراء كمايلي:

١- إضافة سير علوي ضاغط ويوجد به بروز ظاهرة لزيادة الاحتكاك بينة وبين نبات ورد النيل وحصيرة السحب السفلية بهدف خفض الحجم والكتلة ويتحرك بواسطة ثلاث اسطوانات مع ملاحظة زيادة قطر الأسطوانة الوسطى للمحافظة على شد السير وضغطه وسهولة حركته.

٢- إضافة ضاغط في مقدمة فتحة التلقيم والتحكم في مقدار الضغط بتغير قوى السوستة المرتبطة به.

وقد أجريت التجارب بمركز ميكنة الأرز في عام ٢٠١٣ وتم الحصول علي ورد النيل من ناتج المجرى المائي المجاور عند محتوى رطوبي مبدئي 91.5%. ولقد تناول البحث دراسة تأثير كلا من أربع معدلات للتغذية هي ٨ - ١٢ - ١٦ - ٢٠ كجم/دقيقة و أربع سرعات لسكينة القطع هي ٣- ٤.٥ - ٦ - ٧.٥ م/ث (مع نسبة سرعه ثابتة مقدارها ٢٠ : ١ بين سرعة سكينة القطع وسرعة حصيرة التلقيم) وأربع قوى ضغط عند فتحة التلقيم وهي ٢ - ٣ - ٤ - ٥ كيلو نيوتن وذلك على معدل أداء الآلة من خلال تقدير كل من نسبة الكتلة النوعية المفقوده (%) ونسبة الحجم النوعي المفقود (%) وتقدير كفاءة التقطيع للآلة واستهلاك القدرة والطاقة النوعية وسعة

الالة بالطن وبالمتر المكعب ومقارنة الحجم قبل وبعد الفرغ عند الضغوط المختلفة بالإضافة الي حساب تاليف عملية الكبس والتقطيع لورد النيل الطازج (الساق والاوراق) والداله المعيارية للتكاليف.

#### من أهم النتائج التي تم التوصل إليها:

١. سجلت اعلي نسبة مئوية للكتله المفقوده هي ٢٦.٣% وذلك عند معدل تلقيم ٨ كجم/دقيقة وسرعة سكينه القطع ٦م/ث وقوة الضغط ٥ كيلونيوتن وقد لوحظ زيادة نسبة الكتله المفقوده مع زيادة قوة الضغط وزيادة سرعة سكينه القطع من ٣ حتى ٦م/ث. بينما انخفض قليلا الفقد في الكتله بزيادة سرعة سكينه القطع إلي ٧.٥م/ث.
  ٢. سجلت اعلي نسبة مئوية للحجم المفقود وهي ٧٤.٨% عند معدل تلقيم ٢٠ كجم/دقيقة وسرعة سكينه القطع ٦م/ث وقوة الضاغط 5 كيلو نيوتن. بينما أخفضت نسبة الحجم المفقود بزيادة قوة الضغط.
  ٣. كانت اعلي سعه للاله هي ٩.٦ طن/ يوم من ورد النيل قبل الفرغ وتم خفض كتلتها إلى ٧.٧٣ طن/ يوم بعد عملية الفرغ عند معدل تلقيم ٢٠ كجم/دقيقة وقوة الضاغط 5 كيلو نيوتن وسرعة سكينه القطع ٦م/ث.
  ٤. كان الإنتاج الحجمي ٨٣.٢م<sup>٣</sup>/ يوم من ورد النيل قبل عملية الفرغ وتم خفض حجمه إلى ١٩.٦م<sup>٣</sup> عند معدل تلقيم ٢٠ كجم/دقيقة وقوة الضاغط 5 كيلو نيوتن وسرعة سكينه القطع ٦م/ث. وكانت اعلي كفاءة تقطيع لورد النيل ٨٠% وتم الحصول عليها عند اعلي معدلات لعوامل التشغيل المختلفه للآلة.
  ٥. زادت القدرة المستهلكة بزيادة كل من معدل التغذية وقوة الضغط بمقدار ٣٩.٦ ، ٢٧.٧% بينما انخفضت الطاقة النوعية اللازمة لتشغيل الآلة بزيادة معدل التغذية بمقدار ٥٠.٥% وزادت بزيادة قوة الضغط بمقدار ٧٥.٣% بينما انخفضت الداله المعيارية للتكاليف بمقدار ٤٨.٩%.
  ٦. أنخفض الحجم النسبي لورد النيل بعد الفرغ بنسبه ١ : ٤.٢٤ بالمقارنة بحجم ورد النيل الطازج بتكلفه منخفضة مقدارها (٩.٥ جنيه/طن) ويتم تخفيض تكاليف النقل الكلية إلى مصانع الإنتاج بأكثر من ٧٥%.
- مما سبق يتضح أن هذه الآلة يمكن استخدامها في تقليل حجم وكتلة ورد النيل وتحويله إلي منتج يمكن الاستفادة منه في العديد من الأغراض وهي ماكينة تدور بمحرك ديزل صغير (لاتحتاج الي كهرباء) يمكن نقلها علي الترع والمصارف حيث يوجد ورد النيل.

#### قام بتحكيم البحث

أ.د / على السيد ابو المجد

أ.د / زكريا محمد اسماعيل عمارة

كلية الزراعة – جامعة المنصورة

مركز البحوث الزراعية

