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PERFORMANCE EVALUATION OF A LOCALLY DESIGNED AND FABRICATED WINDROW COMPOST TUNER

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ABSTRACT

Windrow composting is the production of compost by piling organic matter or biodegradable wastes, like animal manure and crop residues, in long rows. This method is suited to produce large volumes of compost. These piles are generally turned to improve porosity, oxygen content, mix, control moisture, and redistribute cooler and hotter portions of the pile. The design and fabrication of a local composting turner machine was the main objective in the present study. The machine was modified and fabricated from local materials at a private sector company which was established through the Regional Council for Agricultural Research and Extension in collaboration of Agriculture Engineering Research Institute. The present research work was conducted at Gimaza research station, Gharbia Governorate in spring season of 2005 to test evaluate the machine performance.

Turner drum was modified to use double turner drums instead of one drum. It was modified to improve the materials particles size, porosity, aeration and mixing moisture as well as composting quality. Materials from three crop residues (cotton stalks, corn stalks and rice straw) and animal manure were collected after being cut to small sizes (the average from 5 to 50mm), that's to form windrow (3 m width, 1.7m height and 50 m length). The machine was tested at four forward speeds (2.00, 3.33, 5.00 and 6.70 m/min) and four drum rotational speeds (500, 550, 600 and 650 rpm). The optimum resulting conditions are 650 rpm at forward speed 3.33 m/min., temperature generated 65 °C and moisture content 60 % after wetting the materials pile.

INTRODUCTION

In Egypt, there are many sources for the residuals, which can be used for industrial and agricultural purposes. The total crop residuals were 30 million tons/year (Ministry of agriculture, 2005), animal production residuals were 12 million tons/year and solid waste was 15 million tons/year (HCER, 2004). The 50% percentage from solid wastes was containing organic materials (Hesham, 2002). These residuals caused high environmental pollution. Crop residuals are used in some industries such as wood, paper and agriculture industries represented by organic fertilizer (compost) ... etc. which was a solution to produce safe foods and hence clean life. Composting processing may be medium or large scale and require some equipment to be developed. Turning machine is one of the most important equipment for composting into windrow piles. There are two types of mechanical turner: tractor front mounted and Self-powered or self-propelled. These machines are usually imported and are expensive. The average price ranging from 150,000 to 350,000 LE.

Compost is one of the most important products which may be produced from recycling the solid wastes, crop residues and animal wastes. It improves the condition of the soil and agriculture production. Composting is a waste management option, which utilizes the natural process of biological decomposition to reduce the volume of organic mater to produce a useful soil amendment. The benefits of composting include:

- Reduce volume of residuals to be incorporated in fields.
- Reduce adverse environmental impacts from disposing leaf and yard wastes.
- Decrease disposal costs.
- Produce a beneficial material, compost, which improves the productive potential and condition of soils.
- Conserve the natural resources.

Some basic composting methods, which have been developed, include those that use bins, passive windrows, turned windrow, aerated static piles and in-vessel channels. Turned windrow composting is the production of compost in windrows using mechanical aeration. The compost mix is aerated by a windrow turner, which can be powered by farm tractor (PTO), self-powered or self-propelled. Turned windrow composting represents a low technology and medium labour approach and produce uniform compost. (Ministry of agriculture, food and fisheries - British Columbia, 1996).

Misra, et al. 2004, mentioned that windrow composting consists of placing .the mixture of raw materials in long narrow piles or windows, which are agitated or turned on a regular basis. The turning operation mixes the composting materials and enhances passive aeration. The equipment used for turning determines the size, shape, and spacing of the windrows. Bucket loaders with long reach can build high windrows. Turning machine produce low, wide windrows. A number of specialized machines have been developed for turning windrows. These machines greatly reduce the time and labour involved, mixed the materials thoroughly, and produces more uniform compost. Some of these machines are designed to attach to farm tractors or front-end loaders: others are self-propelled. A few machines also have the capability of loading trucks or wagons from the windrow.

Cornell waste management institute, 2004, reported that, the association of higher turning with lower organic material and higher maturity could be anticipated since turning will help break partial size, homogenize the pile and speed the stabilization process to an extent. There are three turning methods; dedicated windrow turners, bucket loader and passively aerated systems (static non-turned piles). Passively aerated systems were associated with the highest nitrogen and organic matter contents of the three turning methods since without the increased aeration that is provided though the turning, it is more difficult for the oxygen-dependent microbes to break down the organic mater. Wit)ut turning, less of the pile would be exposed to the atmosphere thus; less of the free ammonia-N would be volatilized.

On – Farm Composting of Livestock Mortalities, 2005, indicated that: the moisture is one of the most important aspects of successful mortality composting. A moisture content of 50% to 60% is optimal. Microorganisms require oxygen to decompose compost materials. The target range of oxygen is 5% to 15%. Temperatures between 110 – 150 °F (43 – 65 °C) are acceptable, but any thing above 158 °F (70 °C) may be too hot for compost microorganisms to servive and also reduce the pile moisture to unacceptable levels. The preferred temperature range is 130 – 140 °F (54 – 60 °C) to kill the weeds and pathogens. Composting is effective at pH levels between five to10, with7 being optimum.

Cornell waste management institute, 2006, said that, in many composting operation, a turner my be needed weekly or monthly most of the year, whereas screen and size reduction equipment are generally used intermittently and need to be stored and maintained the rest of the year. For that short windrow, it may not be worth maintenance and storage. There are many types of turning equipment: Front End Loaders – Mixers and Manure Spreaders – Windrow Turners – Push-type Self-powered Rotary Drum and towed behind PTO-powered Turners – Auger-type Turners – Elevating Face Conveyors – Self-propelled Straddle Turners. Windrow turners are dedicated pieces of equipment that just turn compost windrows. The right turner will mix, reduce particle size, homogenize the organic material and may save time and space. Push-type Self-powered Rotary Drum is pushed or pulled through windrows by tractor. These turners have a rotating drum for mixing and aeration and use power from tractor. They are designed to track on the right or left side of the windrow, and require enough space between the rows for the tractor. A tractor with a creeper gear or hydrostatic drive is required to operate these turners.

The main objectives of the present study were-

1-Study chemical properties of some crop residuals and animal manure
2-Design and adapt a prototype of the turner machine
3-Fabricate the turner machine locally.
4-Test and evaluate the machine and analyses the operational cost.

MATERIALS AND METHODS

Composting is one of the main methods to produce organic fertilizer. Composting equipment are essential to process successful composting. Compost Turners is considered the most important among compost equipment.

1- Chemical properties

The chemical properties of the cotton stalk, corn stalk and rice straw as well as the animal manure and final compost as product will be considered

2- Design and construction of the composting turner machine

The following items were considered for turner design:-

1-The turner machine can turn a windrow of 3 m. width and 1.75 m. height.
2-The two drums for turner should improve material fineness.
3-The turner can turn a windrows from any crop residues.
4-Hydraulic system can push the machine and tractor toward the front.

- Components of the compost turner

Figure (1) shows the main components of the compost turning machine. The machine consists of the following main parts:

1- **Main frame**: main frame was fabricated from C channel (140 × 65 mm – 16 kg/m of 20.4 cm^2 cross section) steel 37. Tensile strength (30 - 40 kg/mm^2) and 84 – 137 BHN). Each C channel was covered by welding sheet metal 5 mm thickness on open side. All parts of machine were mounted on main frame. The front end of frame hitches point to hitch the turner machine on the tractor. The deflection gear and hydraulic motor were mounted on the back end of the frame.

2- **Turner unites:** Frame is fabricated from C channel (120 × 70 mm) steel 37. It was covered by 5 mm thickness steel sheet (steel 37 – 39.25 kg/m^2). The turner box is 300 cm width, 175 cm height and 200 cm depth. It can move vertically and horizontally by two links and two hydraulic pastimes. Two turner drums are mounted inside the turner box. The total weight of the turner unit may be calculated from the density of the materials used to fabricate the turner unit.

3- **Pushing unit**: It consists of :- 1- Hydraulic motor; 2- Deflection gear; 3- two tire wheels; 4- Two hydraulic pastimes to move the deflection unit and two tire wheels up and down.

4- **Balance unit**: it is fabricated from two concrete blocks: the first block 150 cm length, 100 cm width and 80 cm height with total weight was 2400 kg. The second block is 103 cm length, 73 cm width and 80 cm height with total weight was 660 kg. (Concrete density used was 2200 kg/m^3) as shown in Fig. (2).

5- **Hydraulic system**: It consists of: 1- supply unit, which will be taken from hydraulic pump of tractor; 2- High pressure roper tubes; 3- Control unit (3 valves). Two hoses, connected to hydraulic pump of tractor one outlet and another inlet to connected to control unit. Three outlets from control unit were connected to the two pastimes turner box, hydraulic motor and deflection unit.

6- **Turner drums.** Rotary drum system is modified to be replaced by two rotary augers. Spring steel knives of 24 cm length × 6 cm width × 10 mm thickness (tensile strength 112 kg/mm^2, 352 BHN) were used. Spring steel knives (60 knives for each drum) were mounted on the two auger drums as shown in Fig. (3). Each auger drums had two directions (right to left and left to right) to collect the compost materials from the end of windrow pile toward the middle of auger drum to rise them up to the second drum and drop down behind it forming the new windrow pile. The primary calculation of turner auger capacity was calculated according to this equation:-

$$Q = 60\frac{\pi}{4}(D_o^{\,2} - D_{in}^{\,2})\rho p n \qquad \text{(El-Sahrigi, 1997) --------------- (1)}$$

Where:

Q = Auger capacity kg/h.

D_o = Outer diameter of the auger, m

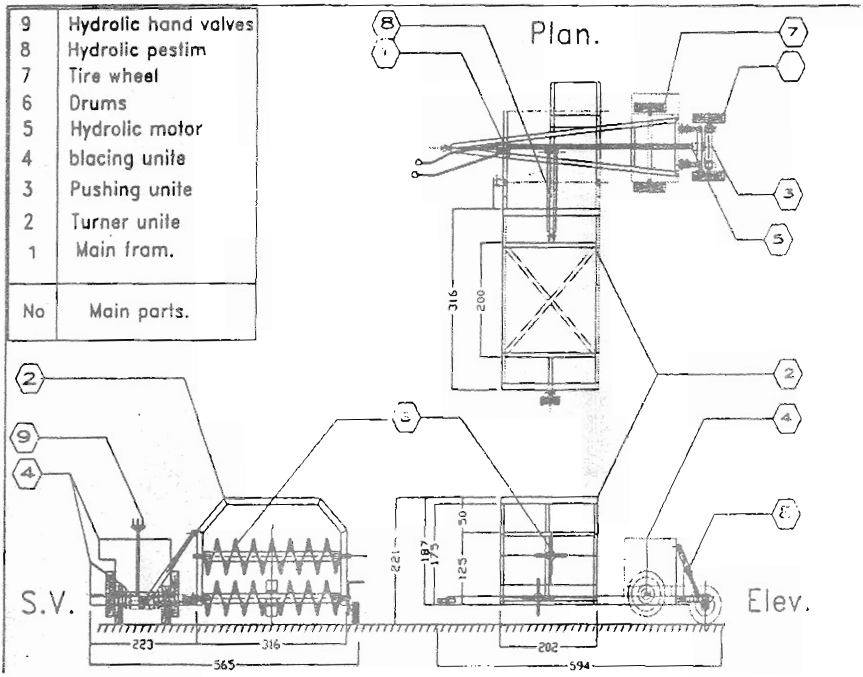


Fig. (1) Main assembly for compost turner components

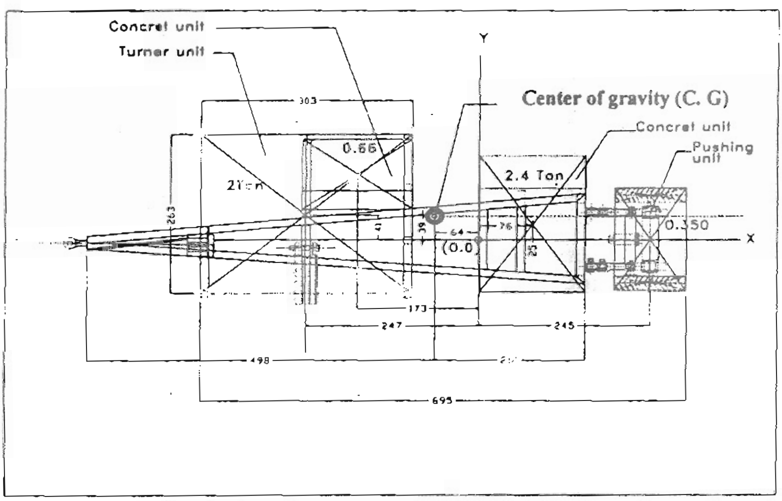


Fig. (2) Diagram for balancing to calculate the center of gravity of the machine

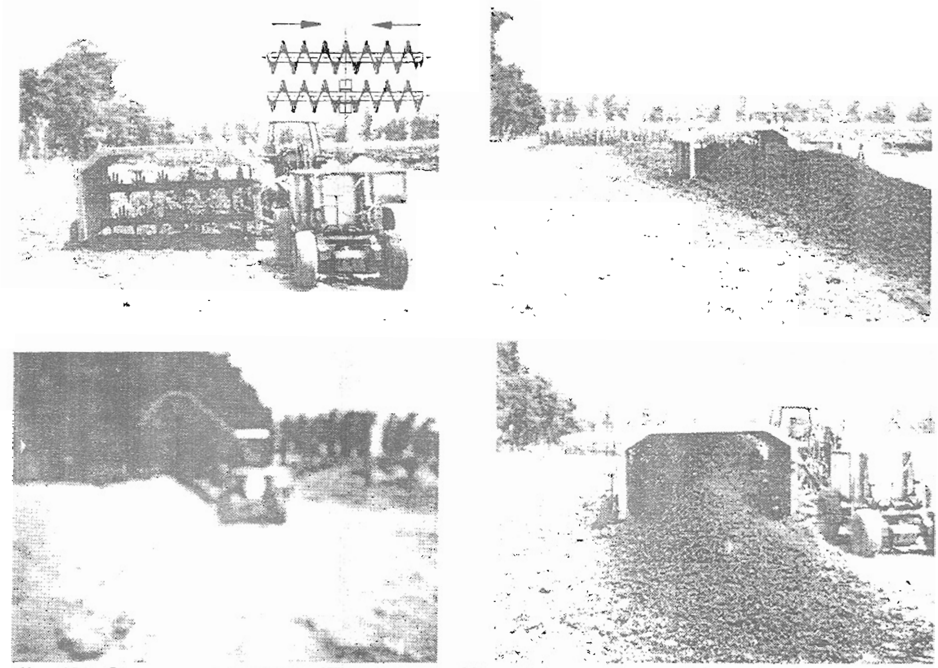
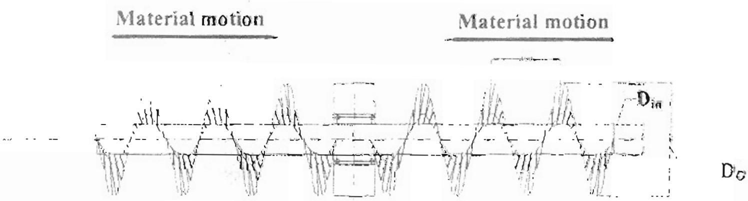


Fig (3) Compost turner (Drum modification and machine during turning the windrow pile



D_{in} = Inner diameter of the auger, m

ρ = Density of the composting materials, kg/m^3

p = Pitch of auger, m

n = Rotational speed rpm × 60 = rph

To determine the auger dimensions assumptions are:-

* The pitch of auger (p) is assumed one or 0.65 of outer diameter of auger

$$p = D_o \text{ or } 0.65\ D_o$$

** The density (ρ) of any material can be calculated from the following equation:-

$$\rho = \frac{m}{v} \quad kg/m^3 \quad \text{------------------------------------} (2)$$

Where:

ρ = The density of material kg/m^3

m = mass of material kg

v = volume of material m^3

Therefore, the capacity of auger and rotational speed can calculated if one of them is known. The length of auger drums is covering the width of turner housing and assumed to be 295 cm. Each drum of the two augers collect the pile materials from the two ends to the mid pile while turning.

-The modification of drum

Most of compost turners has a single auger drum. The present turner machine was modified to contain double drums to improve; (1) Turner operation; (2) Aeration in the pile; (3) Cutting material by increasing the impact between the knives and composting materials. The design and the position of the two drums will be determined by trail and error system. A prototype of the turner machine was fabricated at scaling down and the turner unit was 1 m width × 0.75 height and 0.6 depth. An electric motor (2 HP) was used to run the prototype and rotate the two drums.

Nine preliminary tests (shown in Fig. 4) were run to turn a small pile (100 cm width, 70 cm height and 500 cm length) to select the optimum horizontal position for the double drums. According to Fig. (4). The best position was selected and recommended to apply on the main turner machine. From the view point of pile uniformity, material collection and breakage.

-Theoretical of the turner rat:

According to design the pile over all windrow was 3 m. width and 1.75 m. height and its length was 50 m. The densities for the three materials and animal manure were calculated as: cotton stalks 480 kg/m^3, corn stalks 800 kg/m^3, rice straw 900 kg/m^3 and animal manure 350 kg/m^3. The total weight of the windrow pile can calculate according to:

<u>The area of windrow pile is</u>

Area of the pile = 1/2 width of pile × height of pile

$= 1/2 \times 3\ m \times 1.75 = 2.625\ m^2$

The volume of pile = cross section area of pile × length of the windrow pile

$= 2.6225 \times 50 = 131.25\ m^3 = 130\ m^3$

The total weight of the pile = average density of the pile × volume of windrow pile

$= 632.5\ kg/m^3 \times 130\ m^3 = 82225\ kg = 82.22$ Ton/50 m.

Weight of one meter length of the pile = 1.644 Tan/m

Turner rat = Forward speed × Weight of one meter

= 5.5 Tan/min = 328.5 Ton/h

The relationship between the turner rat and each of forward speed and rotation speed as shown in Fig. (5).

7 - **Tire wheels.** Four tires wheels were mounted on the locally fabricated turner machine, two at the end of the main frame and two at the pushing unit. Tires were selected from tractor small tires list to be suitable with the agriculture conditions (heavy duty, less slippage and long life). The first two tires were used to transmit and pull the turner machine from place to anther by hitching the machine to the tractor. The size of tire is 7.50- 16, type TS-04, outer diameter 80.3 cm, width 20.5 cm, load capacity 1,000 kg and inflation is 325 kPa, number of the ply rating 8 and speed is 0 to 40 km/h. The second two tires were used for pushing the machine during turning the windrow pile. The tire size is 6.5/80-15, type TS-06, outer

diameter 68.5 cm, width 16.3 cm, load capacity 670 kg and inflation is 360 kPa, number of the ply rating 6 and speed is 40 km/h.

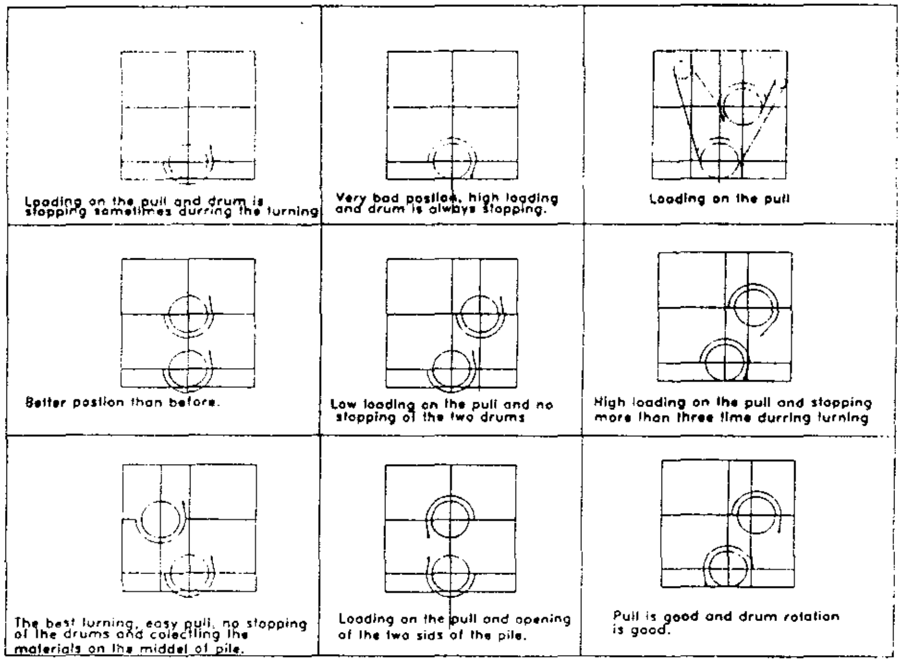


Fig. (4) Primary test diagram of the turner prototype to determine the respective positions of the auger drums.

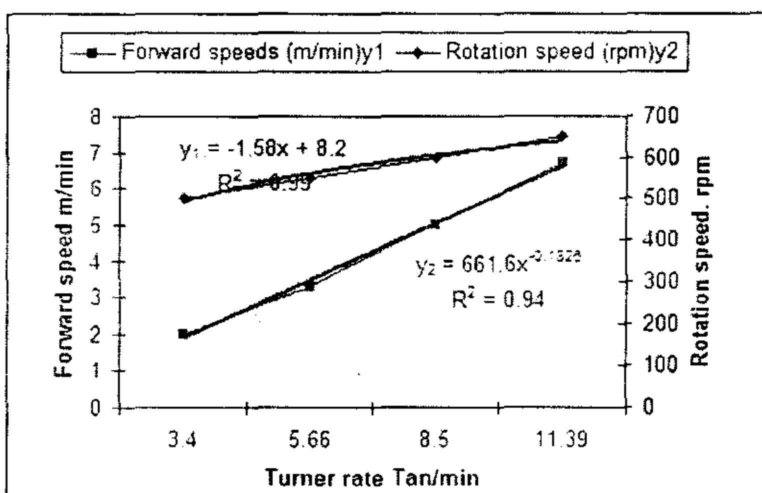


Fig. (5) The relationship between turner rat and forward and rotation speed.

Methods:

Experiments were run at four forward speeds and four rotational speeds (four speeds for each drum).

The forward speeds were 2 m/min, 3.33, and 6.7 m/min. and rotational speeds were 500, 550, 600, and 650 r.p.m.

1- Rotational speed and forward speeds:

Rotational speed was measured by a speedometer, the accuracy of the instrument was one rpm. Before operating the turner, the machine was tested at different rpm (500, 550, 600 and 650 rpm) and each rotational speed was tested with four forward speeds (2, 3.33, 5 and 6.7 m/min.). The speed ratio was calculated according to the equation:

$$S.R. = P.S/F.S \qquad \text{-- (3)}$$

$$P.S = \pi D N$$

Where:-

S. R. = Speed ratio D = Outer diameter of the turner drum (m)

N = Rotation speed P.S = Periphery speed (m/min).

F.S = Forward speed m/min.

2- Center of gravity: The center gravity of turner as the total part was calculated as shown in fig. (2). The point 0 , 0 was assumed to represent two axes X and Y. Torque was taken around point 0 , 0 for the four units. Torque components were considered due to turner unit, pushing unit, first block and second concrete block. X and Y were calculated according these equations:-

$$X = (L_1 \times X_1) + (L_2 \times X_2) + (L_3 \times X_3) + (L_4 \times X_4) / (L_1 + L_2 + L_3 + L_4$$

$$Y = (L_1 \times Y_1) + (L_2 \times Y_2) + (L_3 \times Y_3) + (L_4 \times Y_4) / (L_1 + L_2 + L_3 + L_4$$

3- Density:

It was measured and calculated for each material in the composting pile according equation (2)

$$\rho = \frac{m}{v} \qquad kg/m^3 \qquad \text{-- (2)}$$

4- Temperature

Temperature is most useful parameter when producing compost that indicate the microbes activity. Temperature was measured before turning the pile and before watering at different points in the pile. Compost thermometer instrument was used to measure the temperature inside the windrow pile. The range of thermometer instrument was -10 ^{0}C to 90 ^{0}C, the accuracy was 1^{0}C, it is made in Germany and the length of probe is one meter. One hundred readings were measured randomly from the two sides and middle of the windrow pile and rapidly before each watering and turning. The average temperature was calculated at each measurement.

5- Moisture content

A simple method (gloved hand, squeeze test) was used to determine the need to water of the pile. The simple instrument is a gloved hand "squeeze test" indicate relative moisture content. With the gloved hand, take a hand full of the mixture and squeeze. If more than a few drops of water come out it is too wet. If no drops appear then moisture need to be incorporated (Compost fact shed series 2006). In addition, electric oven was used to measure the moisture content. Moisture percent (wet basis) may be computed as follow:-

$$M.c. = \frac{W_B - W_A}{W_B} \times 100 \quad \text{--} \quad (3)$$

Where:

$M.c.$ = Moisture content % W_B = The weight of the sample before drying

W_A = The weight of the sample after drying.

Moisture content was measured after measuring the temperature of the pile and before turning the windrow pile.

RESULTS AND DISCUSSION

1- Chemical properties: The results of the chemical analysis for composting materials were shown in table. (1) for cotton, corn stalks, rice straw, animal manure and final composting.

Table (1): Chemical properties of crop residues and final composting.

Materials	Limits of the elements %								
	M_c	C	H	O	N	S	Ash	C/N	PH
Cotton stalks	11.5	28.34	5.7	48.5	0.32	0.4	5.24	88.56	6.50
Corn stalks	10.51	27.5	5.8	43.83	0.25	0.19	11.9	110.00	7.00
Rice straw	8.4	38.96	53	36.97	0.99	0.98	8.4	39.35	7.75
Animal manure.		35.55			1.35				8.00
Average.		32.59			0.73			79.3 : 1	
Final Composting		25		6	1.2		8	20.8 : 1	7.5

Before composting: the average of the carbon percentage in the mixture of three crop residuals was 32.59 % and the average of nitrogen was 0.73 %. In the final compost: the chemical analysis results show increasing N % to (1.2 %) and decreasing C % to (25 %). The C/N ratio was 20.8 to 1.0 In addition, the O % was consuming in the analysis microbial and decreasing to 5.5 %. These results indicate that mixing, aeration and active microbial were efficient due to successful turning.

2- Rotational speeds and forward speeds: Composting turner was tested with four forward speeds. Each forward speed was tested with four rotational speeds. The optimum results were at 200 m/h (3.33 m/min) as the forward speed and (600 or 650 rpm) as rotational speed. Increasing the forward speed and decreasing the rotation speed of the two drums caused the turner to windrow pile stopped. The relationship between forward speeds and rotational speed for double drums was affected the machine performance as shown in table (2). The relationship between rotation speed and forward speed during turning operation show that more efficient operation was achieved at lower level of forward speed and higher levels rotational speed (higher drum rpm). Also, increasing the rotation speed cause positive motion that increase the forward speed because the rotation drum rotate in the same direction of the forward speed as shown in fig. (3). The final results show that the optimum rotational speed 650 rpm, and the best forward speed 3.33 m/min.

3- Center of gravity: As shown in fig.(2) The value of point (X. Y) was far away about the point which was assumed by 42 cm on the (X) axis and 26 cm on the (Y) axis.

4- Density: From equation (2) the density before composting for cotton stalk, corn stalk, rice straw and animal manure and the density after composting was as shown in table (3). From table (3) the density after composting decreased as a result to microbial analysis and broken the elements and materials, which consisted the windrow pile.

4- Temperature: There are relationship between temperature and the number of turner. The temperature produced through the composting process is an indicator of microbial activity. If the pile gets too hot, it can kill the microbes- or spontaneous combustion. The average temperature before each turner was measured. The relationship between temperature and number of turning are shown in table (4) and fig. (6).

Table (2): Effect of forward speed and rotation speed combinations on the turner motion.

Rotation S. / Forward S.	500 rpm (1028.35m/min)	550 rpm (1131.185 m/min)	600 rpm (1234.02m/min)	650 rpm (1336.855m/min)
2 m/min	500/2=250 r/m S.R =.514 No stopping and (very slow motion)	550/2.07=267 r/m. S.R =.565.6 No stopping and (slightly increasing the motion)	600/2.14=280r/m S.R = 617 No stopping (increasing the motion)	650/2.22=293r/m S.R = 668.4 No stopping and (increasing the motion)
3.33 m/min	500/3.3=150r/m S.R =.308.8 No stopping (slow motion)	550/3.45=159.4r/m S.R = 339.7 No stopping (slightly increasing the motion)	600/3.57=168 r/m S.R = 370.6. No stopping and (increasing the motion)	650/3.7=175.7r/m S.R = 401.5 No stopping and (increasing the motion)
5 m/min	500/5= 100 r/m S.R = 205.7 Stopping each 3 m. (fast motion)	550/5.2= 106 r/m S.R = 226.24 Stopping each 5m and (slightly increasing of forward speed.	600/5.36=112 r/m S.R = 246.8 stopping each 8m and (increasing of the forward speed)	650/5.56=117 r/m S.R = 267.4 stopping each 12m and (increasing the forward speed)
6.7m/min	500/6.7=75 r/m S.R = 153.5 Stopping each one meter. (very fast motion)	550/6.9=72 r/m S.R = 168.8 Stopping each 1.2 meter. (slightly increasing the forward speed)	/600/7.14=70 r/m S.R = 184.2 Stopping each five meter. (increasing the forward speed)	650/7.4= 68 r/m S.R = 199.5 Stopping each ten meter. increasing the forward speed)

Table (3): The density for some crop residues and composting.

Materials Properties	before composting				after composting
	Cotton stalk	Corn stalk	Rice straw	Caw manure	Mixture Materials
Density kg/m^3	480	800	900	350	550
Average	660				550
PH	6	7.5	7	8	7.5

Table (4): The relationship between temperature and number of turner.

Factor \ Days	Number of turner									
	1	2	3	4	5	6	7	8	9	10
Temperature degree °C	20	40	55	60	65	62	60	45	35	30

Temperatures between 43 – 65 °C are acceptable, but above 70 °C may be too hot for compost microorganisms to thrive and also reduce the pile moisture to unacceptable levels. The preferred temperature range is 54 – 60 °C to kill the weeds and pathogens. (On – Farm composting of Livestock Mortalities, 2005). The temperature increased with increasing the number of turner until turn number five. Then it began to decrease until turning number ten. Microorganisms generate heat when they decompose organic material. The increase affects the composition of the microbial population. Increasing the number of turning and raising the moisture to level 60% in the pile decreased temperature below the undesirable level.

5- Moisture content: Is an important factor to compost processing for the following reasons:-

1- The microbiological activity occurs in a film of moisture content on the surface of the organic material.
2- If temperature in the windrow pile was more than 70° ; C the rate of decomposition begins to decline rapidly as both mesophilic and thermophilic organisms begin to die off.
3-Increasing the moisture content to 60% decreased the temperature.
4-The moisture content after watering the windrow pile was about 60% then began to decrease due to microbial activity inside the pile and increased temperature. When temperature exceed 60 °C and increase to 70 °C the pile need watering and wetting to reduce the heat less than 60 °C to save the microorganism.

The relationship between moisture content and temperature during and between two turnings was as shown in table (5).

Table (5): The relationship in between days (between two turnings No. 4 and 5) and temperature and moisture inside the pile.

Factors. \ Days between two Turnings.	Start turner	Days between two turnings (Turnings no. 4 and 5)					Start the next turning
	First day	Second day	Third day	Fourth day	Fifth day	Sixth day	Seven day
Temperature °C	60	50	40	45	55	60	65
Moisture content %	30	60	50	45	40	30	25

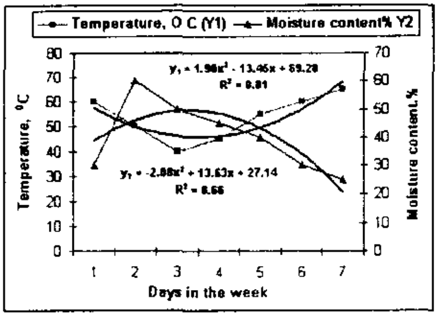


Fig. (6) Relationship between numbers of turning and temperature °C

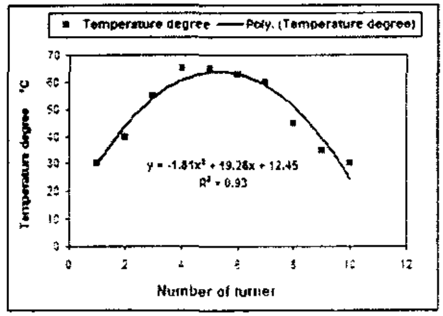


Fig. (7) Relationship between the days (between two turnings) and temperature °C and moisture content%.

CONCLUSIONS AND RECOMMENDATIONS

1- A compost turner unit was designed, fabricated and field tested for optimum operation. The current compost turner design included an additional turning auger that improves turning uniformity, efficiency and increase the degree of particle fineness. Preliminary experiments were run to specify the proper position of the additional auger with respect to the main auger drum. The results of these experiments show that auxiliary auger should be located 75 cm above the main auger (75 cm the distance between two centers) and the center of the new auger should be 30 cm behind the vertical plan crosses the center of the main one. Clearance between the outer two apposite tips of the main and auxiliary auger drums was 10 cm at the vertical level.

2- Turner unit was tested with different forward speeds and different rotational speeds. The optimum forward speed was 3.33 m/min (200 m/h) and the optimum rotational speed for two auger drums was 650 rpm. (1336.855 m/min or 22.28 m/h periphery speed). The best speed ratio between auger periphery speed and machine forward speed was 401.5 to 1.

3- The optimum temperature due to turn the windrow pile was 65 °C and the optimum moisture content 60 % .

4- The average C/N ratio of pile materials was 79.3 to 1 before composting and 20.8 to 1 after composting.

5- The relationship between temperature and moisture content represented by the zone area between the two curves at fig. 7.

6- Temperature increased, moisture content decreased, C/N ratio decreased, oxygen level decreased, broken elements and materials and density decreased due to microbial analysis activity, moisture content suitable and good aeration due to success of the new design to turn the windrow pile.

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تقيم أداء ألة تقليب مصفوفة سماد مصممة ومنفذه محليا

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تعددت مصادر المخلفات الثانوية على العموم والتى يمكن استخدمها فى المجالات الزراعية والصناعية. بلغ اجمالى مخلفات المحاصيل الحقلية ٣٠ مليون طن/السنة وكذلك مخلفات المدن ١٥ مليون طن/السنة. المخلفات الحيوانية تصل الى ١٢ مليون طن/السنة. بعد انتشار الأمراض فى الأونة الأخيرة من استخدام الأسمدة الكيميائية فى الزراعة وزيادة نسبة التلوث فى الطبيعة نتيجة حرق المخلفات أتجه العالم كله الى الزراعة الأمنة بأستخدام الأسمدة العضوية .

تعتبر مخلفات المحاصيل الحقلية والمخلفات الحيوانية المصدر الأساسى لانتاج الأسمدة العضوية ولتحويل تلك المخلفات الى أسمدة عضوية يلزم توافر بعض الألات والمعدات ومن أهمها الة تقليب النمبوست. من هنا اتت اهمية هذه الدراسة لتصميم وتصنيع واختبار الة تقليب محلية الصنع.

فى هذه الدراسة تم اعادة تصميم وتطوير الة التقليب المدفوعة خلف الجرار والتى تستمد حركتها الميكانيكية لأدارة درفيلى التقليب من pto عن طريق صندوق تروس ١ : ٢ وكذلك تستمد مجموعة الدفع الهيدروليكية حركتها من طلمبة الهيدروليك بالجرار المقطورة به المعدة. تم فى هذه الدراسة الأتى:-

--- تصميم عدد أثنين درفيل على شكل الحلزون وذلك لتحسين الأداء – تكسير المواد بالكومة – زيادة معدلات التحلل بالكومة بزيادة معدلات التهوية . درفيلى التقليب ذات اتجاهين لسهولة تجميع المادة المقلبة فى منتصف الدرفيل لسهولة تكويم الكومة وانتظام شكلها.

--- تم تصنيع الألة بعد التصميم والتطوير محليا بأحدى الورش الخاصة تشجيعا للتصنيع المحلى.

--- تم تركيب سكاكين التقليب على درفيلى التقليب على شكل حلزونى.

--- تم تجهيز كومة (مصفوفة) من مخلفات حطب القطن وحطب الذرة وقش الأرز والروث الحيوانى للبقر والجاموس. الأبعاد الكلية للكومة كانت ٣ متر عرض، ١,٧٥ متر ارتفاع، ٢ متر عمق بطول ٥٠ متر.

--- تم التحليل الكيميائى لمكونات الكومة قبل البدء وبعد الانتهاء من انتاج الكمبوست وكانت النتائج كالتالى:–

الخامات	Limits of the elements %								
	ما	ك	يد	أ	ن	كب	رماد	ك/ن	PH
حطب قطن	11.5	28.34	5.7	48.50	0.32	0.4	5.24	88.56	6.50
حطب الذرة	10.51	27.5	5.8	43.83	0.25	0.19	11.90	110.00	7.00
قش الارز	8.4	38.96	53	36.97	0.99	0.98	8.40	39.35	7.75
روث حيوانى		35.55			1.35				8.00
المتوسط		32.59			0.73			79.3 : 1	
الكمبوست النهائى		25.00		6.00	1.20		8.00	20.8 : 1	7.5

--- تم احتبار الألة على تقليب الكومة عند اربع سرعات تقدمية ٢، ٣,٣٣، ٥، ٦,٧ متر/دقيقة وعند كل سرعة تقدمية تم احتبار درفيلى التقليب عند اربع سرعات دورانية ٥٠٠، ٥٥٠، ٦٠٠، ٦٥٠ لفة/دقيقة.

--- تم حساب النسبة بين السرعة المحيطية (للسرعة الدورانية) م/د والسرعة التقدمية م/د.

--- تم حساب معدلات التقليب للمتر الطولى طن/متر وكذلك تم حساب النسبة بين السرعة الدورانية (لفة دقيقة) والسرعة التقدمية (متر/دقيقة) = لفة /متر.

من اهم النتائج:

١- افضل سرعة تقدمية ٢٠٠م /س (٣,٣٣م /دقيقة) مع افضل سرعة دورانية ٦٥٠ لفة /دقيقة بسرعة محيطية (١٣٣٦,٨٥م /دقيقة).

٢- حدوث انخفاض فى كثافة الكومة ٥٥٠ كجم / م٣ وزيادة درجة الحرارة الى ٦٠ م وانحفاض الرطوبة الى ٢٠ : ٣٠ %.

٣ - إنخفاض نسبة الأكسجين داخل الكومة الى ٦ %. كل ماسبق دليل على نجاح الة التقليب فى توفير التهوية الأزمة والاكسجين الكافى لتنشيط تحلل البكتريا هوائيا وتحويل المخلفات الى أسمدة عضوية