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STUDY ON SOME DIFFERENT OPERATING PARAMETERS AFFECTING THE PERFORMANCE OF COMPOST TURNING MACHINES

Dina F.M. Sayed*, M.M. Morad, M.M. Ali and Hend A.M. El-Maghawry

Agric. Eng. Dept., Fac. Agric., Zagazig Univ., Egypt

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ABSTRACT: Experiments were carried out to evaluate the performance of two compost turning machines for producing organic fertilizer by recycling agricultural wastes. To fulfill the objective of this research work, some operating parameters affecting the performance of the two compost turning machines were taken into consideration: Three different types of field crop residues of rice straw, cotton stalks and corn stalks, four different machine forward speeds of 1.0, 1.2, 1.4 and 1.6 km/h, four different turning drum speeds of 150, 200, 250, and 300 rpm and four turning times of 1, 2, 3 and 4 times/month were considered. Evaluation of the compost turning machines was carried out taking into consideration compost density, period to compost maturity, machine productivity, energy requirements and final compost quality. The obtained data revealed that the compost density, the period to compost maturity, the machine productivity, energy requirements and final compost quality were in the optimum range with the use of the self-propelled compost turning machine under conditions of 1.4 km/h forward speed, 250 rpm turning drum speed and three turning times/month. Results also revealed that corn stalks required the least period for maturity of 8 weeks, followed by rice straw of 12 weeks while cotton stalks required the longest period for maturity of 16 weeks.

Key words: Turning machine, agricultural wastes, compost, forward speed, drum speed, machine productivity, energy requirements.

INTRODUCTION

The use of field crop residues for making suitable and safe organic fertilizer will reduce air pollution by avoiding field burning, reduce irrigation water by increasing water-holding capacity, reduce mineral fertilizers consumption and finally help in producing safe food to save human health. **Gonawala and Jardosh (2018)** stated that composting is a method that respects the environment instead of pouring directly into the soil. It is useful method for converting organic waste into useful products that would otherwise have been filled on land. Compost has many benefits such as: reducing landfill space, reducing surface and groundwater contamination, reduce methane emissions, improve the recycling of materials and can be carried out with lower operating costs.

There is an urgent need to add organic fertilizers to both old and new agricultural lands in order to preserve their fertility, especially in hot countries such as Egypt, where organic materials are rapidly decomposing, particularly in desert lands. **Abou Hussein and Sawan (2010)** proved that brewing the agricultural residues in order to produce compost is the perfect method for recycling, aid the organic re-fertilizing to the soil and minimize the production cost. Therefore, the composting process considered as one of the best recycling processes to organic waste to close the natural loop. **Elfeki et al. (2017)** conducted a study focused on the bioconversion of agricultural wastes (AWs) in rural Egypt and analyzed data derived from literature to implement a future image suiting Egypt's situation. Results indicated that bioconversion is suitable to sustainably treat the unused part of AWs, which is about 52% of

* Corresponding author: Tel. :+2 01111844762
 E-mail address: dinafahmoud@gmail.com

a total of 46.7×10^6 tons/year. **Azim *et al.* (2018)** indicated that composting, which utilizes several types of microorganisms, may be used as an alternative method for agricultural waste treatment where it is considered one of low-cost biological decomposition process.

The compost turning in Egypt is still carried out manually, which is tedious and consumes long time with low production, or by many developed technologies, which require high cost. **Michel *et al.* (1996)** stated that turning process supplies some additional aeration, although oxygen levels tend to drop to original levels within a few hours or less after turning. Turning also exposes fresh surfaces for composting by breaking up particles, makes the composting mixture more homogeneous, exchanges material on the outside of the windrow with material from the inside, opens up the structure of the material to produce air spaces, and releases heat, carbon dioxide and water vapor in the form of steam. **Abd El-Mottaleb (2006)** conducted a study on the effect of operational parameters of compost-turner-cum-mixer on the energy requirement. He revealed that by increasing the machine forward speed from 200 to 600 m/h at various rotor speeds led to increase fuel consumption by 14.9 to 19.1 and 26%, the power requirement by 14.9, 23.2 and 26.9%, and the energy requirements by 12.40, 21.50 and 28.10%, respectively, when used the self-propelled turning machine. **Abd El-Mottaleb (2008)** designed and constructed a simple upright compost turning machine suitable for small Egyptian farms. Results showed that optimum operation conditions were observed at forward speed of about 0.8 m/sec. for turning long shape piles and 0.3 m/sec. for turning round shape piles. Rotor speed of about 460 rpm and 4 turnings per month for turning both long and round shape piles. **Morad *et al.* (2008)** developed and locally manufactured a self-propelled compost turning machine from local material to be suitable for Egyptian farms. Their experimental results revealed that final product quality and turning cost were in the optimum region under the conditions of 1500 m/h machine forward speed, 240 rpm rotor peripheral velocity, 100 cm pile height and four turning times per month. **Mani (2012)** developed an indigenously design of tractor

PTO operated windrow turner, which is very useful for mass scale compost production. **Bhat *et al.* (2013)** studied the effect of operational variables of compost windrow turner along with windrow height on the composting of the agro-waste. The results indicated that optimum conditions were straight shaped blades at a rotor speed of 300 rpm operated at the forward speed of 2.26 km/h for a pile height maintained at 1.0 m. Three times turning at a regular interval of 10 days resulted in reduction in density from 514.3 to 299.1 kg/m³.

Concerning final compost quality, **Bhat *et al.* (2014)** studied the effect of Pusa compost inoculant coupled with windrow turner to reduce the time of composting and for producing the better-quality compost. The pile was mixed at regular interval of 10 days using the windrow turner powered by 55.95 kW tractor. The reduction in density as 21.98 and 49.0 % in the subsequent turnings reduced the power consumption from 7.93 to 6.13 kW and composting time to 45 days, **Khater (2015)** studied the physical and chemical properties of compost made of different row materials. Results indicated that the bulk density value ranged from 420 to 655 kg/m³. The water holding capacity values ranged from 3.50 to 4.40 g water/g dry. The total organic carbon values ranged from 16.6 to 23.89%. The C/N ratio values ranged from 14.22:1 to 18.52:1.

There are many types of compost turning machines such as loaders, tractor-pulled turning machines and self-propelled turning machines. The all mentioned machines are complex in construction and expensive. Therefore, such studies had to be carried out to solve the problem of compost turning under conditions of Egyptian farms including the proper adjustment of these machines to optimize their performance. Therefore, the main objective of the present investigation was to use mechanical methods to carry out the turning operation required to convert organic farm wastes into organic fertilizer. To achieve the ultimate goal, the following criteria were taken into consideration:

- Investigate the performance of two different compost turning machines (Tractor-pulled compost turning machine and self-propelled compost turning machine).

- Optimize some different operating parameters affecting the performance of the turning machines (forward speed, turning drum speed and number of compost turning per month) during composting different types of field crop residues.
- Compare the final compost quality with the standard specifications guidelines.

MATERIALS AND METHODS

Experiments were carried out through years of 2018 and 2019 at El-Saad Company, Sharkia Governorate and El-Behera Company, El-Behera Governorate to evaluate the performance of two different types of compost turning machine.

Materials

The used raw materials

Three types of field crop residues: rice straw, cotton stalks and corn stalks were used as a raw material for producing compost. Poultry and livestock manure were also used to accelerate composting process. Added to that finished compost was used as a supply of microorganisms.

Crop residues were collected from the field, cleaned from dust then chopped by using hammer mill. Specifications of the used crop residues are shown in Table 1.

The used crop residues were analyzed in the Agricultural Residues Recycling Unit, Agricultural Research Institute to find fiber fractions such as Hemi Cellulose %, Cellulose % and Lignin %. Chemical characteristics of the used raw materials are shown in Table 2.

The milled and chopped crop residues were mixed with poultry and livestock manure as well as with finished compost to be as a supply of microorganisms. Then the mixture was formed in piles (2m width with 1 m height). After that, piles were turned to expose all material equally to the air at the surface and to the high temperatures inside the pile.

The Compost Turning Machines

The following compost turning machines were used to carry out the present investigations:

The tractor-pulled compost turning machine

The tractor-pulled compost turning machine (Local made at Tanta Motors Company, Egypt) mainly consists of frame, transmission system, distribution unit and turning drum as shown in Fig. 1. The machine was pulled by a tractor as a power source.

The frame

The frame is made of rectangular iron sheet steel. The frame is of 200 cm length, 200 cm width and 120 cm height. The frame includes elements to fix both the distribution unit and the turning shaft. It was carried by two ground wheels of 60 cm diameter.

The transmission system

Power is transmitted from the tractor to turning shaft by means of pulleys, belts, gears and shafts with different reduction speed ratios.

The distribution unit

The distribution unit is a top tank divided from inside into two parts: the first part is used for providing the compost pile with the necessary water for pile humidity during the turning operation, while the other part is used for spraying macro-organization during the same operation.

The turning drum

The turning drum exchanges the material at the windrows surface with material from the interior. The turning drum is of 300 cm length and 65 cm diameter. Bearings are used to support the turning drum in the machine frame. A screw with six blades (Three of them on the right and the other three on the left in opposite directions) are welded and fixed on the turning drum to turn compost materials.

The power source

Tractor four stroke-diesel engine 88 kW (120 hp) was used as a power source.

The self-propelled compost turning machine

The self-propelled compost turning machine (Imported machine, made in Germany) mainly consists of diesel engine as a power source, frame, transmission system, distribution unit and turning drum as shown in Fig. 2.

Table 1. Specifications of the used crop residues

Crop residues	Specifications			
	Average mass, g	Average length, cm	Average diameter, mm	Moisture content, %
Rice straw	50	95	4	8
Cotton stalks	190	120	8	11
Corn stalks	160	150	10	12

Table 2. Chemical characteristics of the used crop residues

Crop residues	Measured value			
	Hemi cellulose, %	Cellulose, %	Lignin, %	Ash, %
Rice straw	9.67	36.57	4.44	12.3
Cotton stalks	10.92	43.20	9.91	5.8
Corn stalks	18.32	44.96	23.34	4.7

**Fig. 1. The tractor-pulled compost turning machine****Fig. 2. The self-propelled compost turning machine**

The power source

Self-propelled, four stroke – diesel engine 132 kW (180 hp) was used as a power source.

The transmission system

Power is transmitted from the engine to both turning shaft and ground wheels by means of pulleys, belts, gears and shafts with different reduction speed ratios.

The frame

The frame is made of rectangular iron sheet steel. The frame is of 200 cm length, 200 cm width and 120 cm height. It includes elements to fix the engine, the gear box, turning shaft, distribution unit and transmission system. It was carried by two ground crawlers.

The distribution unit

The distribution unit is a top tank divided from inside into two parts: the first part is used for providing the compost pile with the necessary water for pile humidity during the turning operation, while the other part is used for spraying macro-organization during the same operation.

The turning drum

The turning drum exchanges the material at the windrows surface with material from the interior. The turning drum is of 300 cm length and 70 cm diameter. Anti-frictions bearings are used to support the turning drum in the machine frame.

A screw with eight blades (Four of them on the right and the other four on the left in opposite directions) are welded and fixed on the drum, while seven individual blades were fixed in the middle of the screw between the two four blades. The eight blades on the screw move the compost material to the middle while the seven blades move and turn material from the top to the bottom.

Methods

Experiments were carried out to study and evaluate the performance of two compost turning machines under different operational parameters.

Experimental Conditions

To cover the objectives of this research work, some operating parameters were taken into consideration.

Two different compost turning machines (Tractor-pulled compost turning machine and self-propelled compost turning machine).

Three different mixtures for composting:

- * Mixture A: rice straw + poultry and livestock manure + finished compost as a supply of microorganisms.
- * Mixture B: cotton stalks + poultry and livestock manure + finished compost as a supply of microorganisms.
- * Mixture C: corn stalks + poultry and livestock manure + finished compost as a supply of microorganisms.

Four different machine forward speeds: 1.0, 1.2, 1.4 and 1.6 km/h.

Four different turning drum speeds of 150, 200, 250, and 300 rpm corresponding to 5.1, 6.8, 8.5 and 10.2 m/s for the tractor-pulled compost turning machine and 5.5, 7.3, 9.2 and 11 m/s for the self-propelled compost turning machine.

Four turning times: 1, 2, 3 and 4 times/ month.

Measurements and Determinations

The compost turning machines were evaluated taking into consideration the following indicators:

Compost density

Compost density was determined according to the following formula:

$$\rho = \frac{m}{v}$$

Where:

ρ - Compost density, kg/m³

m - Compost sample mass, kg

v - Compost sample volume, m³.

Period to compost maturity

The required time from the beginning until the compost maturity (RTCM) was recorded.

Machine Productivity

Machine productivity (MP) was determined using the following formula:

$$\text{Machine productivity} = A \times V \times \eta_{\text{op}}$$

Where:

A - Operational cross-sectional area, m²,

V - Forward speed, m/h,

η_{op} - Operational efficiency, %.

Preliminary experiments were carried out with the two used compost turning machines during the turning operation to obtain their operational efficiency. Results of the preliminary experiments reveal that operational efficiency values were 70 to 80% for the tractor-pulled compost turning machine and 80 to 90% for the self-propelled compost turning machine.

Turning power

The turning power was calculated by using the following formula (Barger *et al.* 1963):

$$\text{TP} = \text{FC} \times \text{CV} \times \eta_{\text{th}} \times 427 \times \frac{1}{75} \times \frac{1}{1.36} \text{ KW}$$

Where:

FC - Fuel consumption, kg/s

CV-Calorific value of fuel, kcal/kg (CV = 10000 kcal/ kg)

427 - Thermo mechanical equivalent, kg.m/k cal

η_{th} - Thermal efficiency of the engine, %

($\eta_{\text{th}} = 30\%$ for diesel engine)

Fuel consumption was recorded by accurately measuring the decrease in fuel level in the fuel tank immediately after executing each operation.

Energy requirements

Energy requirement can be calculated using the following equation:

$$\text{ER, W.h/Mg} = \frac{\text{TP, W}}{\text{MP, m}^3/\text{h} \times \rho, \text{ Mg/m}^3} \times$$

turning times to maturity

Measurement of compost quality

Final product quality was measured in terms of chemical, physical and biological properties for both turning machines.

Random samples of compost, produced by both tractor-pulled compost turning machine and self-propelled compost turning machine were taken to obtain product quality. Compost samples were analyzed in the Agricultural Residues Recycling Unit, Agricultural Research Institute.

Final product quality can be measured as follows:

- Percentage of Nitrogen, %,
- Percentage of organic carbon, %,
- Percentage of organic material, %,
- C/N ratio,
- Water holding capacity, %,

RESULTS AND DISCUSSIONS

The discussion will cover the obtained results under the following heads:

Effect of some Operating Parameters on Compost Density

Effect of machine forward speed

Results showed that machine forward speed affects compost density to a great extent (Fig. 3). Increasing forward speed from 1.0 to 1.6 km/h at constant turning drum speed of 250 rpm and constant 3 turnings per month, increased compost density from 600 to 720, from 610 to 740 and from 560 to 680 kg/m³ with the use of the tractor-pulled compost turning machine for compost mixtures A, B and C respectively. While, from 530 to 600 from 550 to 650 and from 470 to 550 kg/m³ with the use of the self-propelled compost turning machine, under the same previous compost mixtures. The mentioned results agree with Huerta-Pujol *et al.* (2010) who found that the density values were between 447 and 502 kg/m³ for different compost types.

The increase in compost density by increasing forward speed is attributed to that the compost pile did not expose to the required impacting forces per unit time.

This means that increasing forward speed did not give the chance to the drum blades to turn and mix compost pile, resulting in an increase in compost density. The same results show that

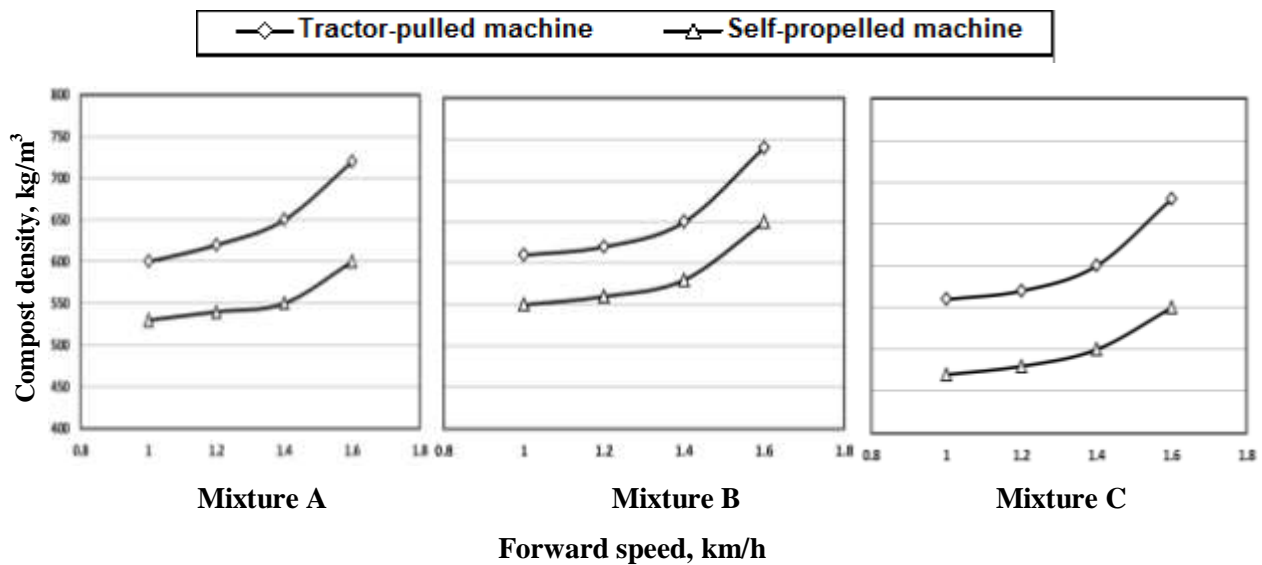


Fig. 3. Effect of machine forward speed on compost density for the three used compost mixtures

compost density values were very close at forward speeds of 1.0, 1.2 and 1.4 km/h. So, a forward speed of 1.4 km/h is recommended to increase machine productivity, reduce the required energy, and approximately achieve the same reduction in density of 1.0 km/h forward speed.

Results also showed that compost density values with the use of the self-propelled compost turning machine are lower than values obtained with the use of the tractor-pulled compost turning machine. This attributed to the number, arrangement and shape of the turning blades which fixed on the turning drum of the self-propelled turning machine compared to the tractor-pulled turning machine.

Effect of turning drum speed

Results showed that compost density is highly affected by turning drum speed. Data obtained in Fig. 4 show that increasing drum speed decreased compost density. Increasing drum speed from 150 to 300 rpm at constant forward speed of 1.4 km/h and constant 3 turnings per month, decreased compost density from 770 to 640, from 750 to 640 and from 720 to 590 kg/m³ with the use of tractor-pulled compost turning machine for compost mixtures A, B and C respectively. While, from 620 to 540 from 650 to 570 and from 560 to 490 kg/m³ with the use of self-propelled compost turning

machine, under the same previous compost mixtures.

Decreasing compost density by increasing drum speed because the high forces that affect compost materials in addition to that the more turning and mixing by the drum blades per unit volume of the disturbed compost, which lead to increase the volume of material resulting in decreasing compost density.

The same results showed that compost density values were very close at drum speeds of 250 and 300 rpm. So, a drum speed of 250 rpm is recommended to reduce the required energy and approximately achieve the same density results of 300 rpm drum speed.

Effect of turning times

Representative turning times values versus compost density are given for different compost mixtures for both tractor-pulled and self-propelled compost turning machines in Fig. 5. Increasing turning times from 1 to 4 turnings per month, at a constant forward speed of 1.4 km/h and constant turning drum speed of 250 rpm, decreased compost density from 790 to 640, from 780 to 640 and from 770 to 590 kg/m³ with the use of tractor-pulled compost turning machine for compost mixtures A, B and C respectively, While from 650 to 540 from 660 to 570 and from 600 to 490 kg/m³ with the use of self-propelled compost turning machine, under the same previous compost mixtures.

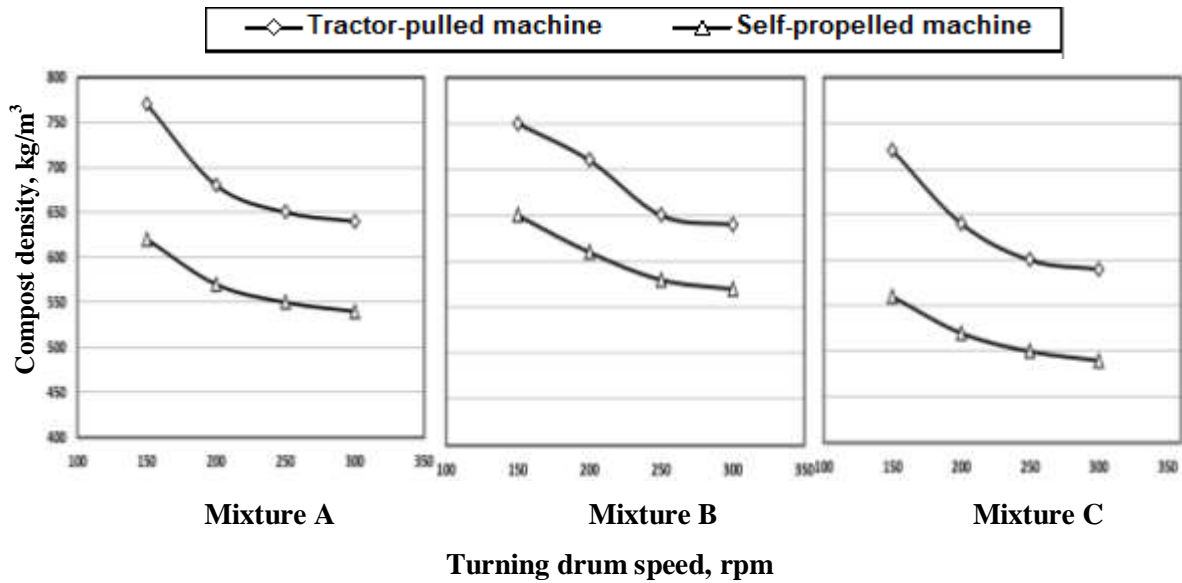


Fig. 4. Effect of turning drum speed on compost density for the three used compost mixtures

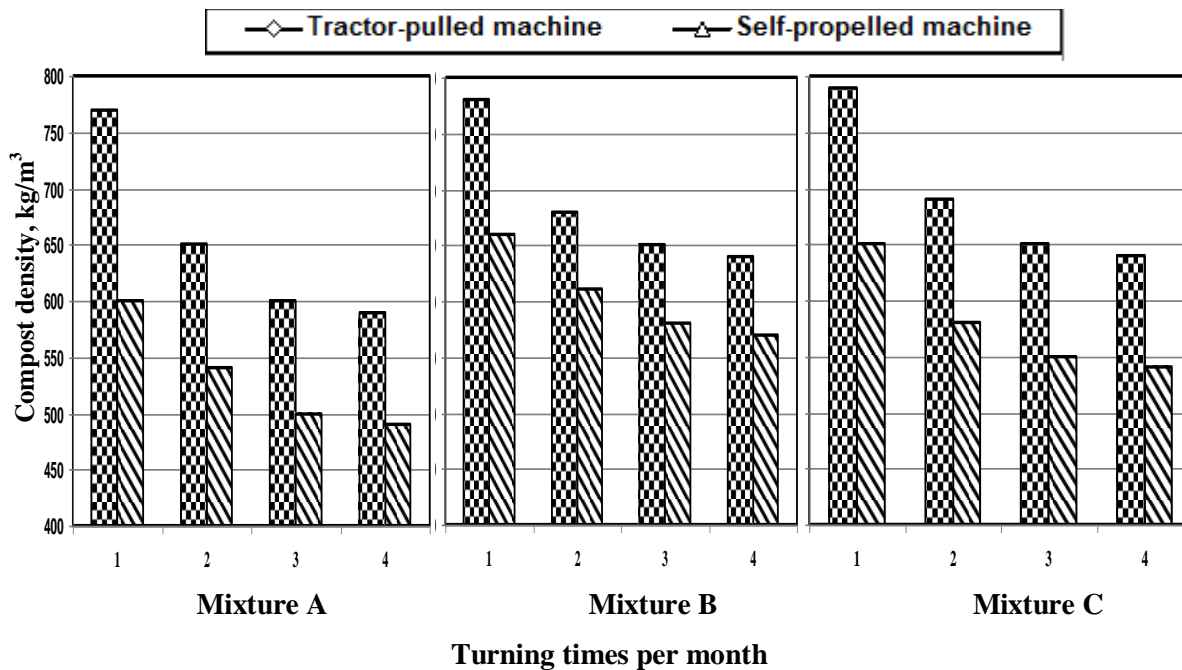


Fig. 5. Effect of turning times per month on compost density for the three used compost mixtures

Decreasing compost density by increasing turning number is attributed to lot of carbon dioxide, heat and water vapor emissions from compost material to air that highly reduce the bloc of the primary material thus compost density.

The same results showed that compost density values were very close at turning times

of 3 and 4 rpm. Therefore, three or four turnings per month are preferred in order to accelerate composting operation and obtain final product as quickly as possible. So, three turning times per month is recommended to reduce the required energy and approximately achieve the same density results of four turnings per month.

Effect of some Operating Parameters on the Period to Compost Maturity

Effect of machine forward speed

Machine forward speed negatively affects the period to compost maturity as shown in Fig. 6. Obtained data show that increasing forward speed increased the period to compost maturity. Increasing forward speed from 1.0 to 1.6 km/h at constant turning drum speed of 250 rpm and constant 3 turnings per month, increased period to maturity from 12 to 28, from 16 to 36 and from 10 to 28 weeks with the use of tractor-pulled compost turning machine for compost mixtures A, B and C respectively. While, from 10 to 20 from 14 to 24 and from 6 to 16 weeks with the use of self-propelled compost turning machine, under the same previous compost mixtures.

The increase in the period to compost maturity by increasing forward speed is attributed to that the compost pile did not expose to the required impacting forces per unit time. This means that increasing forward speed did not give the chance to the drum blades to turn and mix compost pile, resulting in a delay in compost maturity.

The same results showed that the period to compost maturity values were very close at forward speeds of 1.0, 1.2 and 1.4 km/h. So, a forward speed of 1.4 km/h is recommended to increase machine productivity, reduce the required energy and approximately achieve the same reduction in the period to maturity of 1.0 km/h forward speed.

Results also showed that the period to compost maturity values with the use of the self-propelled compost turning machine are lower than values obtained with the use of the tractor-pulled compost turning machine. This attributed to the number, arrangement and shape of the turning blades of the self-propelled turning machine, which are able to interact with the compost pile, resulting in period to maturity reduction, compared to the tractor-pulled turning machine.

Effect of turning drum speed

Results showed that the period to compost maturity is highly affected by turning drum

speed (Fig. 7). Data obtained show that increasing drum speed decreased period to maturity. Increasing drum speed from 150 to 300 rpm at constant forward speed of 1.4 km/h and constant 3 turnings per month, decreased period to maturity from 32 to 15, from 38 to 18 and from 28 to 12 weeks with the use of tractor-pulled compost turning machine for compost mixtures A, B and C respectively. While, from 20 to 11 from 24 to 15 and from 16 to 8 weeks with the use of self-propelled compost turning machine, under the same previous compost mixtures. The decrease in period to compost maturity by increasing drum speed is attributed to the speeding up of compost maturity by the disintegration of compost material, which in turn leads to reducing period to compost maturity.

The same results showed that the period to compost maturity values were very close at drum speeds of 250 and 300 rpm. So, a drum speed of 250 rpm is recommended to reduce the required energy and approximately achieve the same results of 300 rpm drum speed.

Effect of turning times

Turning times values versus period to compost maturity are given at different compost mixtures with the two used turning machines in Fig. 8. Increasing turning times from 1 to 4 turnings per month, at a constant forward speed of 1.4 km/h and constant turning drum speed of 250 rpm, decreased period to maturity from 36 to 14, from 38 to 18 and from 28 to 12 weeks with the use of tractor-pulled compost turning machine for compost mixtures A, B and C respectively. While from 24 to 11 from 24 to 15 and from 16 to 7 weeks with the use of self-propelled compost turning machine under the same compost mixtures.

Decrease period to compost maturity by increasing turning times is attributed to the adequate environment initialization that increase the growth microorganisms' opportunities, leading to speeding up the time to maturity and thus reducing the composting period.

The same results showed that the period to compost maturity values were very close at turning times of 3 and 4 times per month. So, three turning times per month is recommended to reduce the required energy and approximately achieve the same results of 4 turning per month.

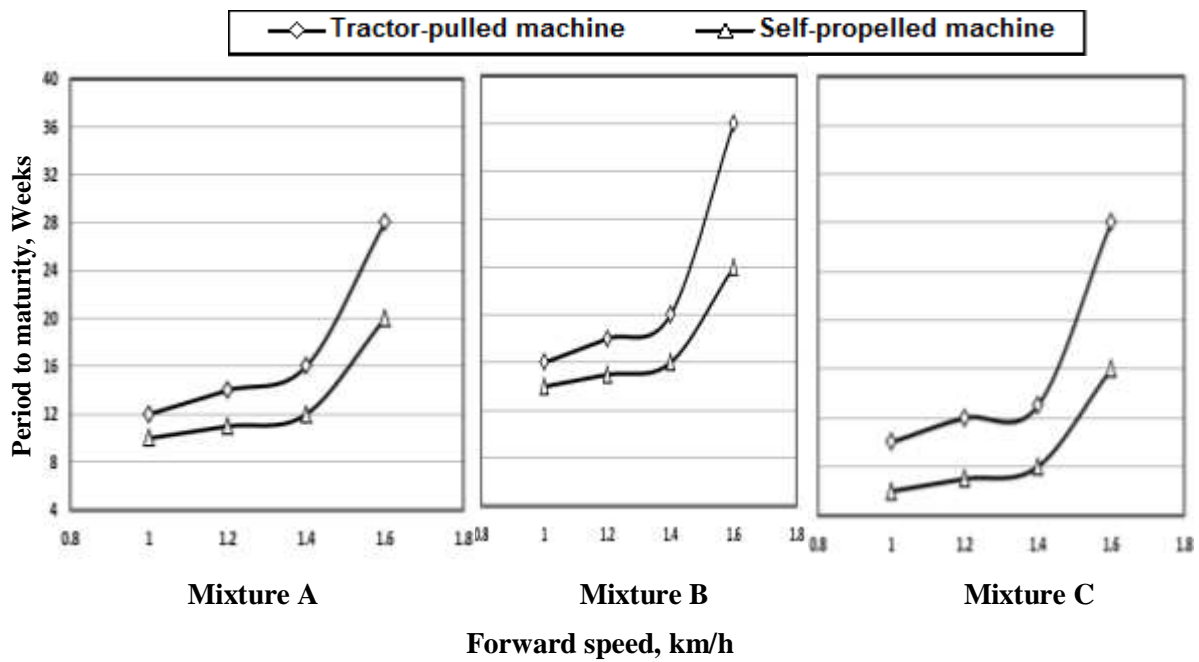


Fig. 6. Effect of machine forward speed on the period to compost maturity for the three used compost mixtures

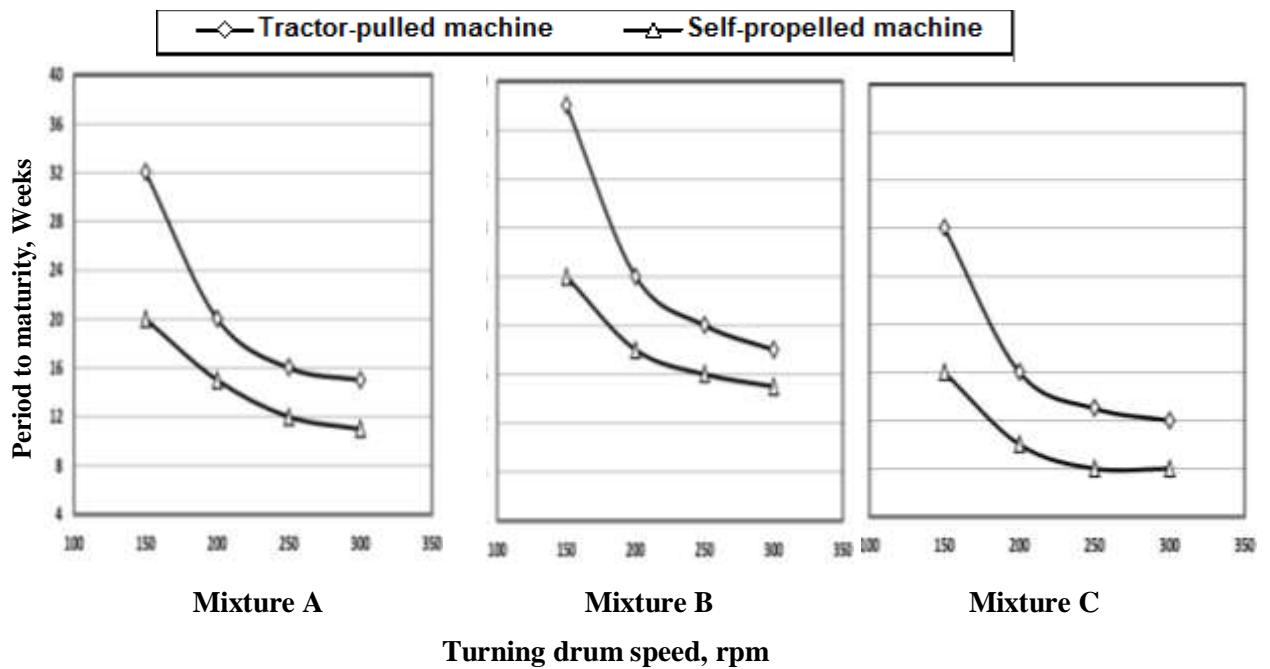


Fig. 7. Effect of turning drum speed on the period to compost maturity for the three used compost mixtures

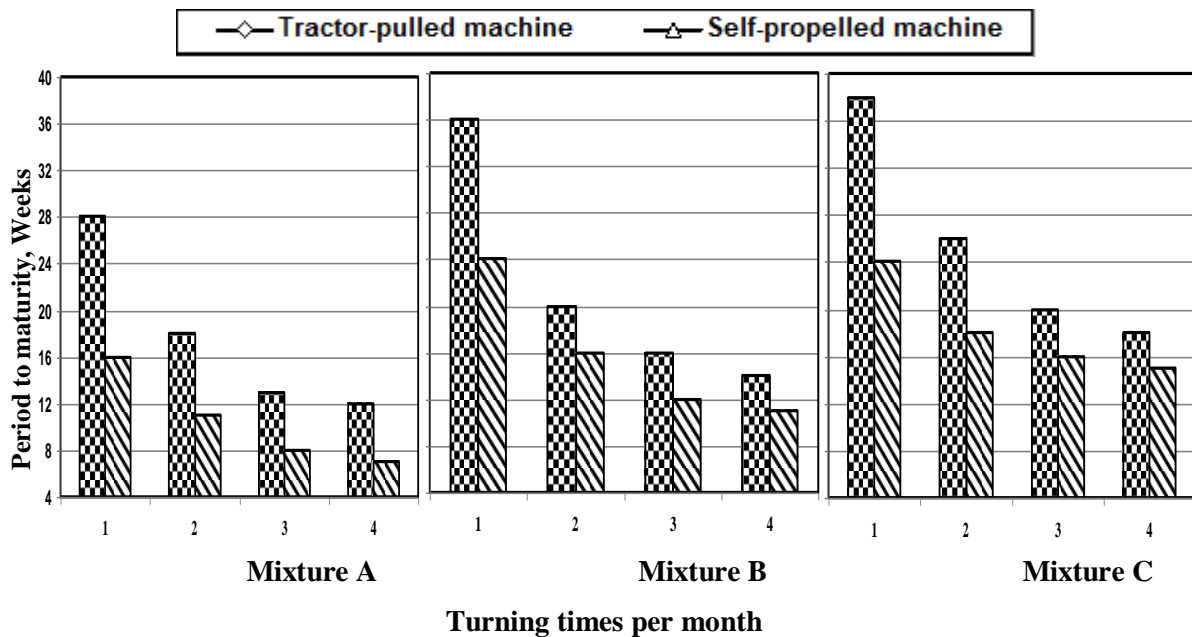


Fig. 8. Effect of turning times per month on the period to compost maturity for the three used compost mixtures

Effect of Machine Forward Speed on Machine Productivity

The most critical factor in productivity of turning machine is its forward speed and its operational efficiency. Machine productivity was calculated under different machine forward speeds and at the recommended turning drum speed of 250 rpm and three turning times per month. Fig. 9 shows the effect of machine forward speed on machine productivity. Results show that increasing machine forward speed from 1.0 to 1.6 km/h, increased machine productivity from 1060 to 1493 m³/h for the tractor-pulled compost turning machine. While increased from 1200 to 1706 m³/h for the self-propelled compost turning machine. The increase in machine productivity by increasing machine forward speed is due to the amount of turning materials rise per unit time.

Effect of Machine Forward Speed on Energy Requirements

Results showed that fuel consumption increased by increasing machine forward speed, which in turn increased the required power. While energy requirements are affected by the required power, machine productivity added to the turning times to compost maturity (Fig. 10).

Energy requirements was calculated under different machine forward speeds at the recommended turning drum speed of 250 rpm and three turning times per month. Data obtained show that increasing machine forward speed from 1.0 to 1.6 km/h, increased energy requirements from 447 to 802, from 586 to 1000 and from 400 to 848 W.h/Mg for the tractor-pulled compost turning machine under compost mixtures A, B and C, respectively. While increased from 373 to 603, from 494 to 668, and from 252 to 526 W.h/Mg for the self-propelled compost turning machine under the same mentioned compost mixtures.

Increasing the energy by increasing forward speed because the compost material overload on the turning drum blades as well as the significant influence of blades on the compost material. Moreover, high forward speeds are accompanied with high turning times to compost maturity that consuming more energy.

The same results showed that energy values were very close at forward speeds of 1.0, 1.2 and 1.4 km/h. So, a forward speed of 1.4 km/h is recommended to achieve high machine productivity with reasonable energy requirements.

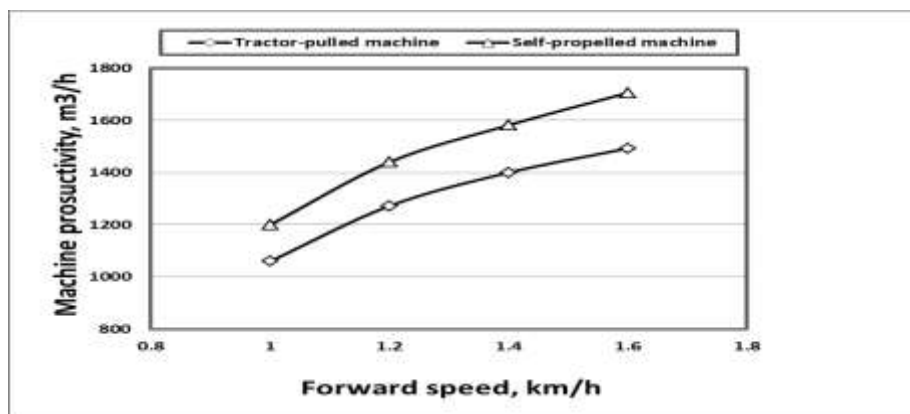


Fig. 9. Effect of machine forward speed on machine productivity

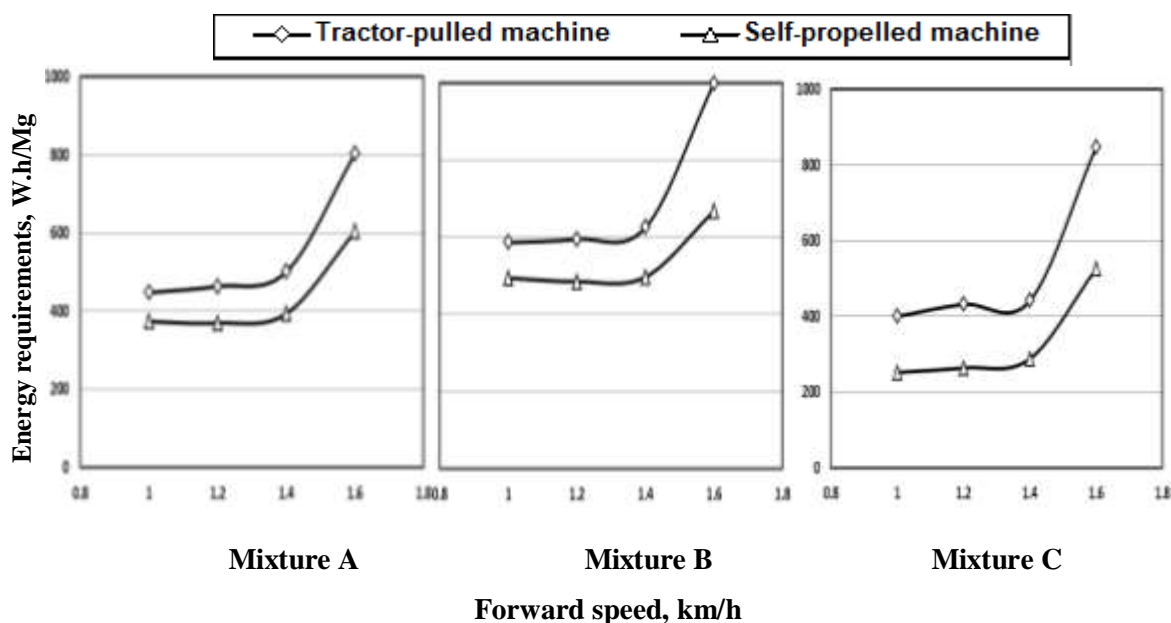


Fig. 10. Effect of machine forward speed on energy requirements for the three used compost mixtures

Results also showed that energy requirements values with the use of the self-propelled compost turning machine are lower than values obtained with the use of the tractor-pulled compost turning machine. This attributed to that the turnings times per month for the tractor-pulled turning machine is higher and consuming more energy compared to the self-propelled turning machine.

Final Compost Quality

Data obtained in Table 3 showed that the final compost quality for Ideal compost and the

compost produced by the two used compost turning machines are approximately similar and very closed to the ideal compost especially with the use of the self-propelled compost turning machine.

This is in agreement with Naidu *et al.* (2010) who showed that at compost maturity carbon/nitrogen (C/N) ratio decreased at the end of composting comparing with the raw materials. They found that C/N ratio of rice straw compost at the beginning of composting process was 30:1 and it was 18:1 at the end of composting period.

Table 3. Final compost quality for ideal and the produced compost from field crop residues

Measured value	Compost			
	Ideal compost	Mixture (A) compost from rice straw	Mixture (B) compost from cotton stalks	Mixture (C) compost from corn stalks
Nitrogen, %	1.75	1.72	1.80	1.85
Organic carbon, %	20.4	19.3	18.0	20.0
Organic matter, %	49.9	47.4	45.8	49.7
C/N ratio	18:1	18:1	20:1	18:1
Water holding capacity, %	240	235	230	240

Conclusion

Experiments were carried out to evaluate the performance of two compost turning machines for producing organic fertilizer by recycling agricultural wastes.

The obtained data reveal that the use of the self-propelled compost turning machine decreases energy compared to the tractor-pulled compost turning machine.

The obtained data also reveal that compost density, machine productivity, energy requirements and final compost quality were in the optimum range under 1.4 km/h machine forward speed, 250 rpm turning drum speed and three turning times per month.

Results also revealed that corn stalks required the least time for maturity of 8 weeks, followed by rice straw of 12 weeks while cotton stalks required the longest time for maturity of 16 weeks.

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دراسة عن بعض عوامل التشغيل التي تؤثر على أداء آلات تقليب الكمبوست

دينا فهمي محمود سيد أحمد - محمد محمد مراد حسن - محمود مصطفى على - هند أحمد مجدى المغاوري

قسم الهندسة الزراعية - كلية الزراعة - جامعة الزقازيق - مصر

يعانى القطاع الزراعي المصري العديد من المشكلات الناجمة عن المخلفات الزراعية بمختلف أنواعها والناجمة عن أنشطة الإنتاج الزراعي، حيث أن التخلص منها عن طريق الحرق يؤدي إلى خفض خصوبة التربة وتلوث البيئة وأضرار صحية للإنسان والحيوان في البيئة المحيطة. وقد أدى التوسع في المساحات المزروعة من الحاصلات الزراعية المختلفة وزيادة أعداد الحيوانات المزرعية إلى زيادة المخلفات الزراعية بكميات كبيرة الأمر الذي دفع إلى البحث عن طرق آمنة للتخلص منها أو إعادة استخدامها للحصول على منتجات مفيدة مثل استخدامها في إنتاج سماد عضوي (كمبوست). لضمان كفاءة عملية إنتاج الكومبوست تستخدم آلات للتقليب بهدف إتمام عملية التهوية وسهولة الترطيب بالماء والمنشط البكتيري. ومن ثم فقد أجري هذا البحث بهدف تقييم أداء آلتين من آلات تقليب الكمبوست (آلة ملحقة بالجرار وآلة ذاتية الحركة). وقد تم تقييم أداء الآلات المستخدمة تحت عوامل تشغيل مختلفة شملت نوع المخلف الزراعي (قش الأرز - حطب القطن - حطب الذرة) والسرعة الأمامية للآلة والسرعة الدورانية للدرفيل وعدد مرات تقليب الكومات السمادية. وقد تم تقييم المعاملات أخذاً في الاعتبار كل من كثافة السماد وفترة النضج والسعة الإنتاجية للآلة والطاقة المستهلكة وجودة الكمبوست الناتج. وكانت أهم النتائج المتحصل عليها ما يلي: أن كل من كثافة السماد، وفترة النضج، وإنتاجية الآلة، ومتطلبات الطاقة، وجودة السماد النهائي كانت في حدود القيم المنطقية في حالة استخدام آلة تقليب الكمبوست ذاتية الحركة تحت ظروف التشغيل التي يوصى بان تكون السرعة الأمامية للآلة 1.4 كم/ساعة والسرعة الدورانية للدرفيل 250 لفة/دقيقة وعدد مرات التقليب 3 مرات شهرياً. و تطلبت سيقان الذرة أقل فترة نضج (8 أسابيع)، يليها قش الأرز (12 أسبوعاً) بينما تطلبت سيقان القطن أطول فترة للنضج (16 أسبوعاً).

المحكمون:

- 1- أ.د. احمد فؤاد عبد المطلب رئيس بحوث هندسة النظم الحيوية- معهد بحوث الهندسة الزراعية-مركز بحوث الهندسة الزراعية
- 2- أ.د.محمود عبد العزيز حسن استاذ الهندسة الزراعية المتفرغ- كلية الزراعة- جامعة الزقازيق