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Abstract

In order to assist organic farming, the effective utilization of manures is required. Recognizing the need and importance of pulverization of manures, the Department of Farm Power Machinery and Engineering developed and tested the manure pulverize and optimized the manure parameters. The machine consists of pulverizing drum, pulverizing blades, sieve, feeding hopper and supporting frame. Dried manures were fed into the pulverizing drum from the machine hopper through its feeding chute and it gets pulverized due to the rotation of the pulverizing blade. The average capacity of the pulverizer was 500.00 kg h^{-1}. Efficient moisture content values obtained for cow dung, goat fecal pellet and neem cake were 20.93%, 16.70% and 14.20%, respectively. The complete testing analysis of the machine indicated that KAU manure pulverizer performed efficiently with the use of 5 mm sieve with 15 mm clearance for all types of dried manures tested.

Keywords: KAU manure pulverizer; Manures; Fineness modulus

Fig. 1 KAU Manure Pulverizer

Introduction

Manures are plant and chemical waste that are used as a source of plant nutrients. There are number of organic manures like farmyard manure, green manures, compost prepared from crop residues and other farm wastes, vermin compost, oil cakes and biological wastes − animal bones, slaughter, house refuse etc. Organic production methods are based on specific standards precisely formulated for good production and aim to achieve an agro ecosystem, which are socially and ecologically sustainable. It is based on minimizing the use of external inputs through the use of on farm resources efficiently compared to industrial agriculture.

As manure dries, nutrients are not only concentrated on a weight basis, but also on a volume basis due to structural changes. Compared to the fresh manure, it is easier to handle and transport the dried manure because of decreased volume and weight (Salikutti, 2006). Furthermore, dehydrated manure has a consistent texture and is easier to apply to gardens. Dehydrated manure has a lower pathogen and weed seed content than the fresh manure. When manure dries up to 10-17% of moisture and is applied into a fine soil, nutrients are more concentrated and the soluble salt level is probably higher in dehydrated manure than in locally available farm manure (Babu et al., 2008). Thus the evaluation of pulverizer becomes inevitable. While recognizing the importance of the need for powdering the dried manures, Kerala Agricultural University (KAU) has developed a machine named "KAU Manure Pulverizer" to pulverize the dried organic manures such as cow dung, neem cake, biogas slurry, and goat and rabbit fecal pellets etc.

Table 1 Efficiency of pulverizer with different moisture content of manures

Item	Sample	Moisture content (%)	Input (kg)	Output (kg)	Time (sec)	Efficiency (%)
Cow dung	1	28.00	10.00	9.67	86.30	96.70
	2	16.36	10.00	9.71	78.80	97.10
	3	20.93	10.00	9.81	67.60	98.10
Goat fecal pellet	1	16.70	10.00	9.85	71.00	98.50
	2	24.48	10.00	9.75	84.33	97.50
	3	10.82	10.00	9.65	56.32	96.50
Neem cake	1	14.20	10.00	9.85	61.31	98.50
	2	26.90	10.00	9.79	120.80	97.90
	3	20.70	10.00	9.61	84.32	96.10

Materials and Methods

2.1 Description of the Machine

The KAU manure pulverizer mainly consists of a prime mover, pulverizing drum, feeding chute, power transmission unit, pulverizing blade, sieve and supporting stand as shown in **Fig. 1**. A single phase electric motor (1.5hp, 1440 rpm, 230V, 10A and 50Hz) was used as the prime mover for the developed pulverizer. Two double V-belt pulleys were used for power transmission from the electric motor to the main shaft. One of the main parts of the machine is the pulverizing drum which is made of M.S sheet of 52 cm diameter and 30 cm height in which dried manures are pulverized by impact and cutting forces of the pulverizing blades. A trapezoidal feeding chute of 565 cm length is provided to feed the dried manures. The rotary shaft is fitted with four blades that are fixed inside the pulverizing drum. It has a length of 22 cm and width of 4 cm and is made up of EN8 flat of 6 mm thick. The blades are fitted to the bottom of the shaft using a nut. It is sharpened on one side at an angle of 45°. A 5 mm square mesh or 10 mm opening mesh was provided at the bottom of the pulverizing drum. It was supported by a MS sheet of size 52 cm × 2 cm × 0.4 cm that was welded to the supporting frame located below the pulverizing blades. A clearance of 1.5cm is provided between sieve and pulverizing blade to easily collect the pulverized manures. The supporting stand was made with four angle irons of size 5 cm × 5 cm × 0.6 cm that were of height 65 cm. **Fig. 2** presents the orthographic projection of the KAU manure pulverizer.

2.2 Working Principle of the Machine

The dried farmyard manures are filled in the drum through feeding chute. The feed rate was controlled through the means of a cap provided at the top cover. Upon starting the electric motor, the main shaft rotates along with the blades inside the drum. Due to the rotation of the blades, the dried manure gets crushed within the small clearance provided between the sieve and the pulverizing blades (Nwoguet al., 2013: Etamaihe and Iwe, 2014). Power from the electric motor was transmitted to the main shaft by means of double V-belt pulley. Effective crushing is achieved by providing a tapering at one side of the blade (Gbabo and Ndagi, 2014). The powdered manures pass through the sieves which were collected at the bottom part of the machine. The dried manures will remain inside the drum until it attains a size smaller than the size of the holes in the sieve.

2.3 Moisture Content

Moisture content is the percentage of water present in a given manure sample. The oven dry method was used for the determination of moisture content. Pulverizing manure is collected in a clean container and is placed in an oven under controlled temperature conditions of 105-110 °C for a period of 24 hours.

$$\text{Moisture content, \%} = [(M_1 - M_2) / M_2] \times 100\% \quad ...(1)$$

where,

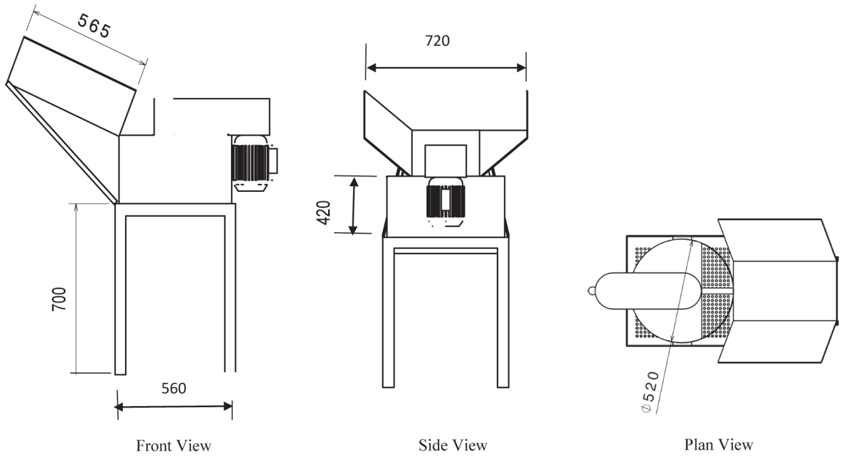
M_1 = initial weight of the manure, g

M_2 = final weight of the manure, g

2.4 Capacity of the Pulverizer

The capacity of the machine is considered as the amount of pulver-

Fig. 2 Orthographic projection of the KAU manure pulverizer (All dimensions in mm)



ized manure per unit time (Nwaigwe et al., 2012). In order to calculate the machine capacity, manure was fed into the machine for six known period of time viz. 10, 20, 40, 50 and 60 seconds. The time taken was observed using a stopwatch and the weight of the pulverized manure in each period was recorded. Knowing the time required and weight of the pulverized manure, the machine capacity was calculated as:

Capacity, kg h^{-1} = (weightofpulverizedmanure, kg) / (timeofoperation, h) ...(2)

2.5 Efficiency of the Pulverizer

The efficiency of the pulverizer was considered as the amount of pulverized manure per kg of dried manure as feed.

2.6 Fineness Modulus of the Powder

Fineness modulus is an index number which represents the mean size of particles in pulverized manure. It is calculated by performing sieve analysis with standard sieves (Thomas, 2006). The sieves used for the fine sieve analysis are 2 mm, 1 mm, 600µm, 425µm, 300µm, 212µm, 150 µm and 75 µm IS sieves. The sample weights retained on each sieve were recorded. The cumulative weight retained on each sieve was used to determine the cumulative percentage retained on each sieve. Adding all the cumulative percentage values together and dividing it by 100 will give the value of fineness modulus (Opath, 2014).

Results and Discussion

The test was carried out to determine the capacity of pulverizer, efficiency of operation and optimization of manure parameters according to pulverizer efficiency. The average capacity of the pulverizer was observed to be 500.00 kg h^{-1}. **Table 1** presents the efficiency results obtained for the pulverizer using different moisture contents of manures.

From **Table 1**, it can be deduced that increase in moisture content of cow dung from 16.36% to 20.93% increases the efficiency from 97.10% to 98.10%. However, further increase in moisture content beyond an optimum limit causes further decrease in efficiency due to adhering nature of manure. This is evident in the case of increasing the moisture content of cow dung to 28% which brought down the efficiency value to 96.70%. The result of using goat fecal pellet as shown in **Table 1** was almost similar to that of cow dung except for the highest moisture content involved which produced an efficiency whose value fell in between that of the efficiency values corresponded to 10.82% and 16.70% moisture contents. But in the case of cow dung the highest moisture content of input produced an efficiency below the efficiency values obtained for 16.36% and 20.93% moisture content. Whereas in the case of pulverizing neem cake, efficiency value decreased from 98.50% to 96.10% when the moisture content of neem cake increased from 14.20% to 20.70%. Further increase in moisture content to 26.90% from 20.70% increased the efficiency value to 97.90%.

Fig. 3 shows the relationship between efficiency and moisture content for the different manures used

Fig. 3 Efficiency – Moisture content relationship

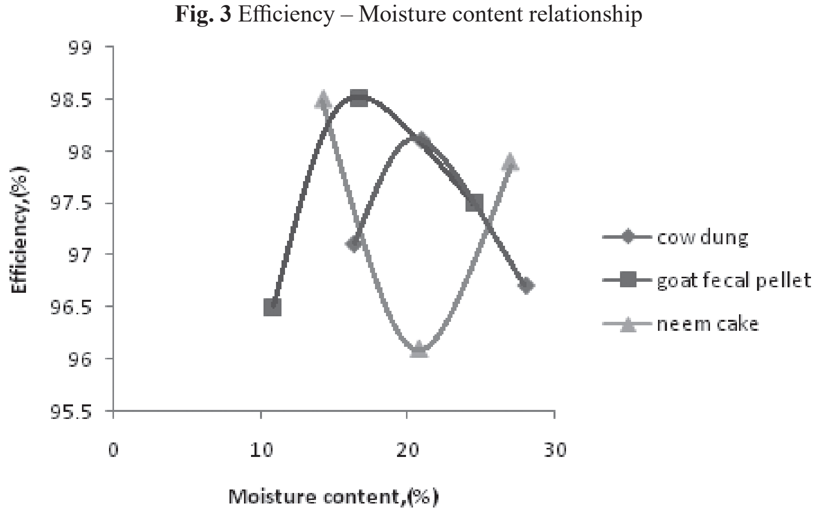


Fig. 4 Variation of efficiency with clearance at 5 mm sieve size

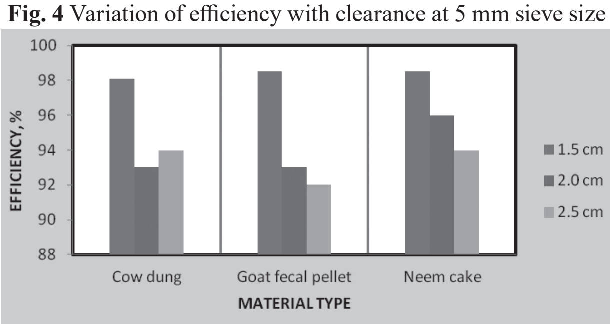
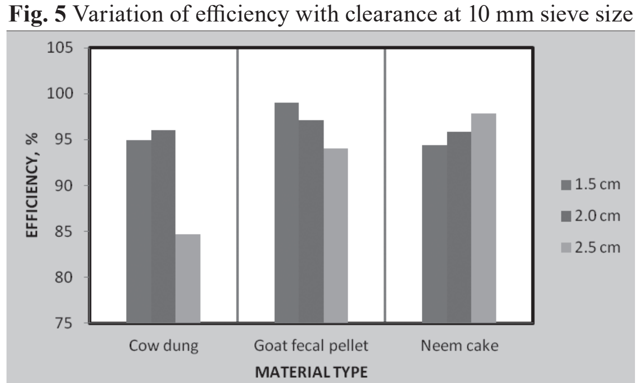


Fig. 5 Variation of efficiency with clearance at 10 mm sieve size



to evaluate the machine. It can be seen that the goat fecal pellets produced the highest efficiency value of 98.50% while neem cake produced the least efficiency value of 96.10%.

Also presented in **Figs. 4** and **5** are the bar charts showing the relationship between efficiency and the material type with the corresponding values of sieve size of 5 mm and 10 mm, respectively. Test was carried out in both 5 mm and 10 mm sieves at 1.5, 2.0, 2.5 cm clearance respectively. In the 5 mm sieve size higher efficiency was obtained at 1.5 cm clearance for all manures whereas in 10 mm sieve variations were observed in the efficiency values obtained with respect to the type of manure and clearance used.

For the determination of fineness modulus, different pulverized manures with different moisture content from different sieve sizes and clearances were collected and it was carried out in the laboratory. The pictorial views of the powdered form obtained for cow dung, goat fecal pellet and neem cake during machine testing are presented in **Figs. 6**, **7** and **8**, respectively.

Conclusions

A KAU manure pulverizer was developed and tested for its performance. Results showed that the KAU manure pulverizer was highly efficient in pulverizing goat fecal pellets with less time of operation. It works efficiently with a clearance of 1.5 cm between sieve and the pulverizing blade and is mostly suitable for goat fecal pellet.

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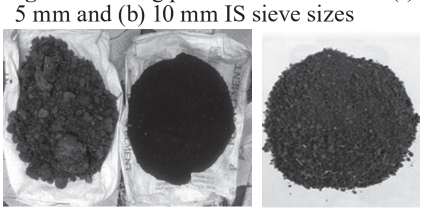
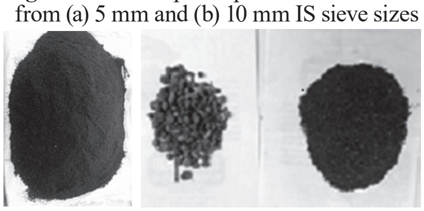
Fig. 6 Cow dung powder observed from (a) 5 mm and (b) 10 mm IS sieve sizes



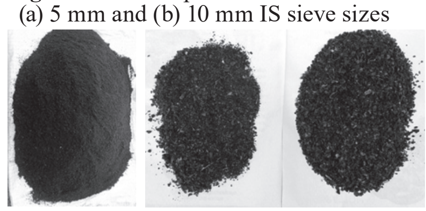
(a) (b)

Fig. 7 Goat fecal pellet powder observed from (a) 5 mm and (b) 10 mm IS sieve sizes



(a) (b)

Fig. 8 *Neem* cake powder observed from (a) 5 mm and (b) 10 mm IS sieve sizes



(a) (b)