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Determination of Physical Properties of FYM for the Development of FYM Shredder cum Spreader

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ABSTRACT

A research work was undertaken at the Department Agricultural Engineering, Regional Agricultural Research Station, Tirupathi, Andhra Pradesh, India during 2020 to study the physical properties of FYM for the designing the tractor mounted FYM spreader. Application of FYM increases the soil fertility. FYM contained almost all essential nutrients required for soil. The important FYM physical properties like moisture content, bulk density, angle of repose, coefficient of friction are required for development of FYM shredder cum spreader. The FYM is heterogeneous mixture and its moisture content varies at different depths stored in manure pits for measuring the physical characteristics, three depths of manure pits viz., 0–20, 20–40, 40–60 cm collected and were used. Designing The physical properties found in FYM like moisture content, bulk density, angle of repose and coefficient of friction and sieve analysis of FYM at different depth of manure pit were 61% db 20% wb,0.650 g cm^{-3},71.03 and 34° respectively. The initial bulk density form before the operation 0.650 g cm^{-3}andclod size is major at 70% at 50 mm screen opening after shredder operation the bulk density decreases 0.250 g cm^{-3} and 40% of FYM retained less than 10 mm sieves at the shredder speed is 255 RPM. The developed shredder was successful in reducing 70% aggregation size from more than 50 mm-less than10 mm sieve opening which is desirable form of FYM application.

KEYWORDS: FYM, moong, nutrient management, organic, panchgavya, vermicompost, vermiwash

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

In India precision forming includes precise nutrient management. India is home to 30% of total organic produces in the world having 2.30 mha in 2021. The organic area in India is 2.5 mha (Anonymous, 2012). The organic farming is gaining the improve in which chemicals, synthetic fertilizer, and growth regulators. The various concepts to ensure soil health like revaluation, manuring, application of compost mulching etc.(Choudhary et al., 2016, Anonymous, 2012; Allaire and Parent, 2004). organic forming significant job to improve the physical properties, expanding soil aggregation, water holding capacity, hydraulic conductivity etc. (Singh and Thomas, 2010). As agriculture is facing the issues of loss of fertility, soil degradation and soil health, the consumption of FYM as organic materials is the best mode to recover it (Mohan et al.,2022). It increments improvement of soils physical properties like soil structure, bulk density, infiltration, porosity and water-holding capacity and natural activity. It also provides a source for immediate supply of nutrients and slow releases of nutrients as well. It also lower the pH of soil and reduces the water and wind erosion.

The FYM consists almost all the essential nutrients required for soil, help them maintain C:N proportion in the soil, increases the fertility and soil's physical and biological characteristics. Nutrient contents of FYM are 0.5% of Nitrogen, 0.2% of Phosphorus, 0.5% of Potash and Moderate Micronutrients (Reddy,2005; Thakur et al., 2015). This FYM is transported to filed and placed as a heap further distribution and it should be spread uniformly over soil surface and mixed completely. Then FYM should be applied 15–20 days before sowing or transplanting so that manure goes under ammonification and nitrification process. Usage levels ranges between 2–5 t ha^{-1} for most of the crops, however it may go high as 25–50 t ha^{-1} (Vinayak et al., 2022) for vegetables sugarcane etc.Manure application has been an integral portion of agriculture for centuries. Correct evaluation of manure spreaders saves money by controlling the rate at which manure is applied on the field. This will prevent over fertilization and minimize nitrogen loss to soil and climate. Use of manpower for application of FYM more economical i.e.6–8 labours per acre (Glanceyand Hoffman,1996) and in this process may lead to crop over yielding or sometimes may crop damaged, the work performance in the field alters with the change in the application of manure. In other Nations, the field activities are mechanized where as in India the traditional methods are performed to carry out the field activities such as usage of Bullocks and trolleys are used to carry and drop the manure as heap wherever it is required in the field manually (Duhovnik et al., 2004). These dumps are later spread around manually with spades, which it is an uneconomical and tedious procedure (Thakur et al., 2015). The present method of leaving manure in small piles scattered with in the area prior to the field application for a very long period lead to loss of nutrients. These losses can be reduced by spreading the manure. The problem faced in the application of manure with the domestic method is the non-uniform application rate and non-disintegration of large manure clumps(Jain and Lawrence, 2015).The objective of the present research to study the physical properties of FYM for the designing the tractor mounted FYM spreader.

2. MATERIALS AND METHODS

The research work was carried out at the Department Agricultural Engineering, Regional Agricultural Research Station, Tirupathi, Andhra Pradesh, India during2020.The FYM is heterogeneous mixture and its moisture content varies at different depths stored in manure pits. For measuring the physical characteristics, three depths of manure pits viz., 0–20, 20–40, 40–60 cm collected and were used. The detailed procedure for the measurement of physical properties of dry FYM was described. The detailed procedure for the measurement of physical properties of dry FYM was described.

2.1. Moisture content

FYM samples of each 10 g were taken in a known weight of container and placed in the hot air oven at 105°C and dried for 24 h this procedure replicated three times. Dried samples along with containers were weighed and noted down. Moisture contents of samples on wet basis were measured by using the formula.

% Moisture content (wet basis)=(weight of undried sample-wieght of dried sample)/Weight of undried sample .....(1)

Dry matter content: The dry matter content (solid matter content) of the manure represents the proportion on a mass basis of the dissolved and suspended materials in the manure. Manure gradually becomes non-Newtonian with increasing total solids content (Lagueet al.,2005).

It is expressed using the formula as:

Dry matter (%)=100-Moisture content of manure (%) ....(2)

2.2. Bulk density

The bulk density of the manure is expected to have an effect on the spreading distance, clod size distribution and application rate. The bulk density was found out by measuring the volume of given weight of the sample. It was calculated by mass of manure (kg) by volume of cylinder (m^3). The bulk density of the FYM was determined by using the standard procedure. A core sampler of 9 cm diameter and 12 cm height was taken and driven vertically into the pit by gently hammering the wooden plate placed over it.

Bulk density (kg m^{-3})=(Weight of the sample in cylinder (Kg)/(Volume of the container (m^3) ………..(3)

Coefficient of static friction is measured by using inclined plane method. Coefficient of static friction of FYM is measured for plywood, galvanized iron and tarpaulin sheet. The coefficient of static friction was calculated as the tangent of angle of inclination (α) and is given by the following equation."

$\mu = \tan(\alpha)$ ……..……(4)

2.3. Determination of particle size distribution

Unlike soil sample sieve analyser, a modified soil sieves shaker and a screen set were used to determine the larger particle aggregates size distribution of FYM samples. Collected sample of FYM was weighed and pass through a different set of sieves. Aperture size of sieves was range 50, 40, 30 20 mm and less than 10 mm as shown in Figure 1. The samples were placed on the top screen and shaken for 90 s as shown in Figure1. FYM retained on each screen was weighed on a laboratory scale. The weight of the FYM retained on each sieve was observed and tabulated. The same procedure was repeated for all the treatments by operating at desired levels (Landry et al., 2013).

Figure 1: Apparatus for measuring the sieve analysis

2.4. Development of shredder for FYM aggregates

The main challenge of application of FYM in the field is spreading from the heap and pulverizing FYM lumps in to small pieces and shredding. These lump sizes vary from 10 mm, 400 mm is applied as it is (in lump form) this nutrient exchange in to the soil will take even one season. To get benefit out of the FYM applied it is dire essential to make in to the smaller particles and spread in the field (Sahu et al.,2020,Sahuet al.,2020).Hence, the shredder unit is designed to pulverize or make in to smaller particle/slices before application.

2.5. Spreader unit

Shredding is the process of mechanically breaking down the congregated bulk amount of FYM in to a much smaller particle size. The mechanical aeration allows for better volatilization by reducing the particle size and thus exposing more surface area to the atmosphere. The mechanical shredding unit was designed and consists of beating roller, beating element and deflector. The beating roller consists of 22 mild steel flanges at four rows with equal spacing around roller apart from four rows, two rows consists of 6 flanges remaining rows with 5 flanges at equal spacing. The beating roller diameter 150 mm with 1800 mm length. Provision was made to fix 22 numbers of elements with 4" length on the flange by using bolts and nuts the CAD view shown in Figure 2. The entire assembly was mounted on the above the main frame using thrust bearings at height of 300 mm the shredder from the main frame.Theshroud fixed with a metal sheet 1800 mm×470mm around the shredding area power transmission for the shredder unit was connected through gearbox output shaft through belt pulley and optimized. The speed of shredder roller was varied for the better performance of unit (Kothari etal., 2018).

2.6. Beating element

The flexible MS chain was used as beating elements. This chain consists of each link 25 mm length diameter 5mm the length of the chain (2,4 and 6 links) were selected for study and optimized through experiments conducted to final the effects of beating element length on the parameters of the FYM.

The power for the shredder unit was transmitted from the tractor PTO. The drive from the PTO (540±10 RPM) was transmitted through the gear box to V belt pulley. The speed was further decreasing from output shaft of gear box.

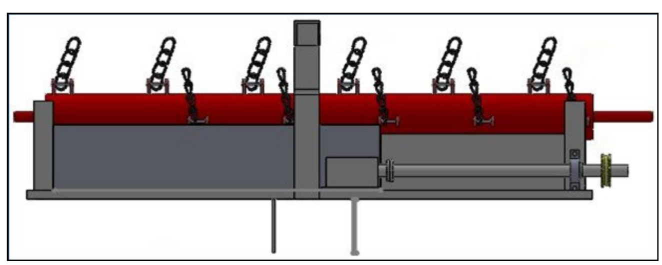

Figure 2: Beating roller and beating mounted on the main frame CAD view

3. RESULTS AND DISCUSSION

3.1. Physical and engineering properties of FYM

The various physical properties of the FYM were measured and the average values are tabulated (Table 1).

Table 1: Physical and engineering properties of FYM

Sl. No.	Physical properties of FYM	
1.	Moisture content (%)	40
2.	Dry Moisture content (%)	60
3.	Initial Bulk density (g cm-3)	0.610
4.	Angle of repose (°)	48.5
5.	Coefficient of friction	0.87

3.2. Particle size distribution of FYM

The sieve analysis of the FYM aggregates was measured as discussed in previous section and the average values are obtained. More than 70% of the material retained over 50 screen opening is shown in figure 3. That clearly indicates that the FYM aggregates need to be pulverized before application for better ionization and nutrient enhancement.

3.3. Optimization of machine parameters for better pulverization

The developed shredding machine was experimented with selected variables like beating roller speed, (25 mm) beating element length (3 levels). The data was analysed and values were depicted and tabulated.

3.4. Effect of machine and operational parameters on bulk density shredder speed at 180 RPM

The mean bulk density obtained for the different treatment combinations at 100 mm discharge gate opening and 2, 4 and 6 (chain links) beating elements are used. It was observed that the bulk density decreased number of chain links. The lowest bulk density of 0.512 g cm^{-3} was obtained at 100 mm discharge gate opening and 4 no of chain links (Thakur et al., 2015) (Table 2).

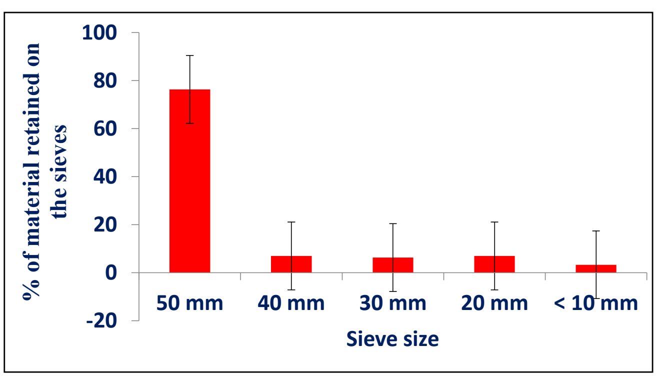

Figure 3: Showing all size of particle before shredding

Table 2: Mean bulk densities at shredder speed at 180 RPM

Shredder speed	No. of chain links	R_1	R_2	R_3
	2 chain links	0.521	0.530	0.536
	4 chain links	0.515	0.512	0.517
	6 chain links	0.516	0.528	0.532

3.5. Effect of beating rollers and operational parameters on bulk density shredder speed at 255 RPM

The mean bulk density obtained for the different treatment fixed discharge opening and 2, 4 and 6 (chain links) beating elements were used. It was observed that the bulk density decreased number of chain links and increased shredder speed. The lowest bulk density of 0.503 g cm^{-3} was obtained at 100 mm discharge gate opening and number 4 of chain links (Table 3).

Table 3: Mean bulk densities at shredder speed at 255 RPM

Shredder speed	No. of chain links	R_1	R_2	R_3
255 RPM				
	2 chain links	0.614	0.600	0.549
	4 chain links	0.511	0.503	0.508
	6 chain links	0.568	0.611	0.623

3.6. Optimization of beating rollers speed for minimum bulk density

Based on the experimental results, the treatment combinations of fixed discharge opening and 4 no. of chain links yielded minimum bulk density presented in Table 4.

Table 4: Best combination beating roller speed and beating element length for minimum bulk density

Shredder speed	No. of chain links	R_1	R_2	R_3
180 RPM	4 chain links	0.515	0.512	0.517
255 RPM	4 chain links	0.511	0.503	0.508

3.7. Optimized beating rollers speed and beating element length % of 0–10 mm clod size distribution

From the above table it is evident that the among selected speeds 180 RPMand 255 RPM the maximum % of small particles found in 255 RPM. This may be due to the high impact force developed due to peripheral velocity (2 ms^{-1}) (Venkat et al., 2021, Thakur et al., 2015). It also observed from the data that among the lengths of beating elements 4 links lengths created more % of smaller pieces, whereas the 2 links length than 6 link lengths larger lumps are retained (Vinayak et al., 2022) (Table 5 and figure 4).

Table 5: Best combination for minimum % of clod size distribution

Beating roller speed	Number of chain links		
	2 chain links	4 chain links	6 chain links
180 RPM	5.66	16.00	10.00
255 RPM	16.33	57.66	43.93

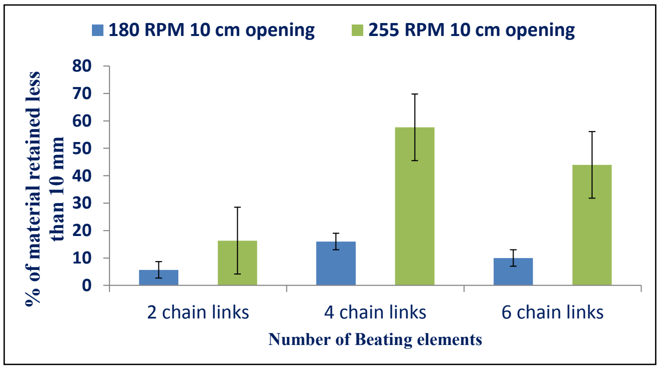

Figure 4: Best combination for minimum percentage of clod size distribution

4. CONCLUSION

The physical properties of FYM used for the experiment were measured the moisture content is 40%, dry moisture content is 60%, initial bulk density is 0.610 g cm^{-3}, angle of repose is 48.5 degrees, coefficient of friction is 0.87 and sieve analysis is more than 70% of the material retained over 50 screen opening. TheBulk density decreased with increase in shredder rpm and number of chain links.

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