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Development of Tractor Mounted FYM Spreader

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***Abstract*:** The application of FYM in the field is carried out traditionally lead to uneven distribution, increases cost and labour requirements. The developed machine consists of the manure tub, FYM conveyor unit, manure discharging gate, shredding and spreading unit. The conveyor unit passes FYM from manure tub in to the shredder unit with the help of belt conveyor through the manure discharge gate and manure discharge gate provided to change levels of opening from the bottom of conveyor belt. The shredding unit is mounted on the mainframe. Flexible chains are used as beating elements. The shredder collects FYM material from top surface further it directs to the openings designed in such way that the material is evenly spread on the field. The developed machine was evaluated for field performance with the optimized variables derived from the experimental trials is the conveyor speed, bulk density and clod size distribution. The optimized parameters were conveyor speed is 48 RPM, beating roller speed 255 rpm, bulk density and clod size distribution were observed as 0.503 g cm^{-3} and 57.66 % at 100 mm discharge gate opening with 4 chain links respectively. The discharge rate was 4.9 t/h at 100 mm manure discharge gate opening belt speed at 48 rpm.

***Keywords*:** FYM, Belt conveyor, Manure control gate, FYM Shredder, Distribution unit, Bulk density, Sieve analysis

India precision farming includes specific nutrient management. The organic farming in country approximately covers 78 million hectares. Organic manure such as green manure, farm yard manure etc. In India production and accessibility of FYM is about 2850.503 lakh tonnes which is more as compared to other manure production (SOFI 2021). 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. The utilization of manure has been able to be mechanized in other nations like other field activities but in India, the innate strategies are still taken after, i.e., stacked trolley or bullock truck is moved inside the field and stopped at regular interval where a man other than the driver empties small amount of manure and drops it in the form of a pile. 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. The objective of the study to develop tractor mounted farm yard manure shredder cum spreader and performance evaluation of the developed unit.

MATERIAL AND METHODS

Conceptual design of proposed FYM spreader: See Fig 1

Design and construction of components of FYM spreader: FYM spreader attachment to the existing tractor trailer of RARS, Tirupati consists of

a) Two-wheel tractor-trailer b) Manure tub c) Conveyor unit d) Discharge control gate e) Shredder unit f) Power transmission unit g) Housing The details and specifications of the components were as follows.

Two- wheeled trailer and manure tub: The trailer was provided with two pneumatic tyres of size 10 × 20 16 PR to support the loaded trailer the hitch of the trailer was provided with central members. At bottom of the trailer belt conveyor system is fixed with both the two end rollers, there rollers are powered through chain drive The FYM shredder unit and spreader unit assembly of the mounted at the front portion of the trailer. The entire arrangement was fitted with bolts and nuts to the trailer frame which can be dismantled. This is done to enable to use as trailer, when not in use as FYM spreader.

FYM Conveyor unit

Conveying of FYM from manure tub in to the shredder unit by the help of belt conveyor through the discharge gate. Compared to other types of horizontal conveying system, the initial cost of belt conveying system is competitive or low, lighter in weight, and consumes less power and operate without noise, give a continuous discharge. Hence reasons belt conveyors were used to carry the FYM from tub to

shredder unit. The belt was made with canvas unit cloth and driven by rollers (both front and rear). The belt conveyor unit consists of a belt, drive mechanism, and end rollers, spacers and control system.

Manure discharge control gate: Discharge control gate is mounted on the front side of the manure tub. Flow control gates are designed to provide controlled discharge of bulk amount of FYM from manure tub. Discharge control gate was used for regulating and metering the flow on conveyor belt and gate was designed in front side of the manure tub and useful in metering the flow of material on belt. It consists of two sections i) Gate section and ii) Channel section Gate section is fixed to the channel with latches provided on gate and these gates slide over the lower section the channel. Restriction of gate movement was made not to lower beyond 50 mm so as to protect the conveyor arrangement. The gate opening height was calibrated for accurate application of manure.

Shredder unit: The shredder unit mainly consists of a main frame, baffle plate, beating rollers and spreading mechanism. Main frame the basic structure on which whole shredder unit was mounted and was fabricated in rectangular shape with 63 mm iron L-angles of 1800 mm × 470 mm. Four vertical L angles risers with 63 mm and 300 mm height arranged at each corner of the main frame for the purpose of creating resting point to the beating roller shaft. The baffle plate was designed in between conveyer belt and beating roller to direct the feed (FYM) from the conveyor belt to beating unit will not only delays dropping time for improving shredding and also gives double effect on pulverization. The beating roller consisted of 22 mild steel flanges arranged in four rows with equal spacing around roller and apart from each row. Provision was made to fix 22 numbers of beating elements flexible chains with each link length 25 mm flanges by using fasteners. The speed optimization is necessary for the better performance of shredder unit. Energy transmission through shredder element makes FYM lumps in to small pieces and further shredding was enhanced by hitting to shrouding sheets of the unit.

Spreading unit: The shredder FYM material collected at bottom was further directed to the bottom and openings are designed in such way that the material is evenly spread on the field.

Housing: All the components of FYM spreader system except conveyor assembly were mounted on a rectangular housing and made to rest on the trailer connecting shank including gear box and related power transmission assembly.

Power transmission to beating roller and conveyor system: Power transmission was designed to transmit the power from prime mover i.e. PTO shaft and to the gear box of the developed mechanism. The chain drive system was used for this purpose. In this power train first stage of transmission from prime mover i.e. PTO shaft to gear box to shredder unit (initially the belt drive was designed and off late changed to chain drive). In second stage power transmission, power was further connected from shredding unit shaft to conveyor roller shaft. The speed was reduced from half shaft of gear box to 255 rpm on the shredder unit. The number of teeth on driving sprocket wheel having 18 cm diameter (36 teethes). The drive from the shredder unit transmitted to belt conveyor further decreases from 255 shredder to 48rpm available at the belt conveyor unit shaft. All the speeds of the rotating components were ascertained by tachometer.

Optimization of operational parameters: It is desirable to study the effect of operations designed on FYM conveying, shredding and spreading. Certain tests were conducted to obtain optimum operational parameters conveyor speed, peripheral speed shredder, shredding element length per flange of beating roller and discharge opening positions on the clod size distribution and application rate.

The bulk density and sieve analysis were considered as an index of FYM pulverization and it measured after each experiment. The size of sieves was range 50, 40, 30 20 mm and less than 10 mm. The samples were placed on the top screen and shaken for 90 seconds. 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. In order to ascertain the partial size of FYM when it was spread with developed machine.

Development of prototype FYM pulverizer cum spreader: A prototype tractor mounted FYM shredder cum spreader was developed. The optimized values of machine and operational parameters obtained from the tested levels of variables were incorporated for required out come and fabricated the FYM spreader.

RESULTS AND DISCUSSION

Effect of conveyor speed on the discharge rate: The experimental results among the treatment combinations of manure discharge gate opening at 100 mm and at 48 RPM speed of conveyor speed yielded discharge rate 4.9 t h-were are used in confirmation with the requirement of the yield expressed by Singh et al (2013 and Kothari Kunal et al (2018).

Effect of beating rollers and operational parameters on clod size distribution beating roller speed at 180 RPM: The shredder 180 RPM and number of chain links increased the percentage of minimum clod size distribution ranging from less than 10 mm (Fig. 11). The highest percentage of 16

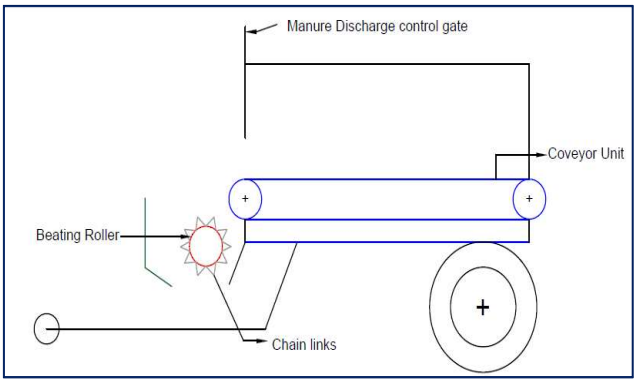

Fig. 1. Conceptual diagram of FYM spreader

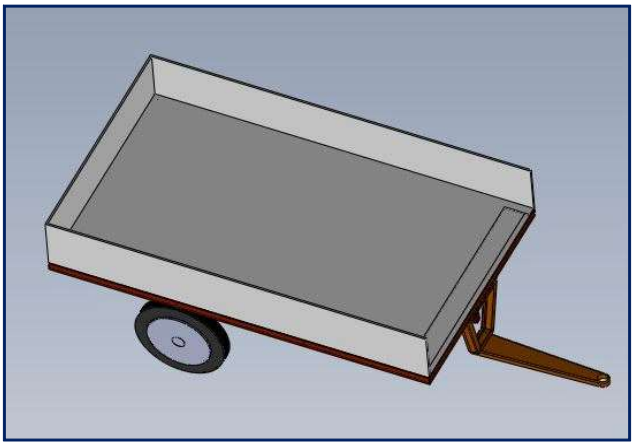

Fig. 2. Two- wheeled trailer and manure tub CAD view

Fig. 3. FYM conveyor unit

Fig. 4. FYM flow control gate

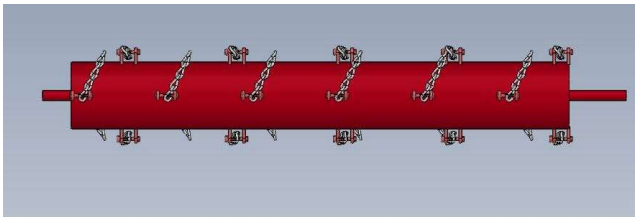

Fig. 5. Beating roller and beating elements CAD view

Fig. 6. Housing

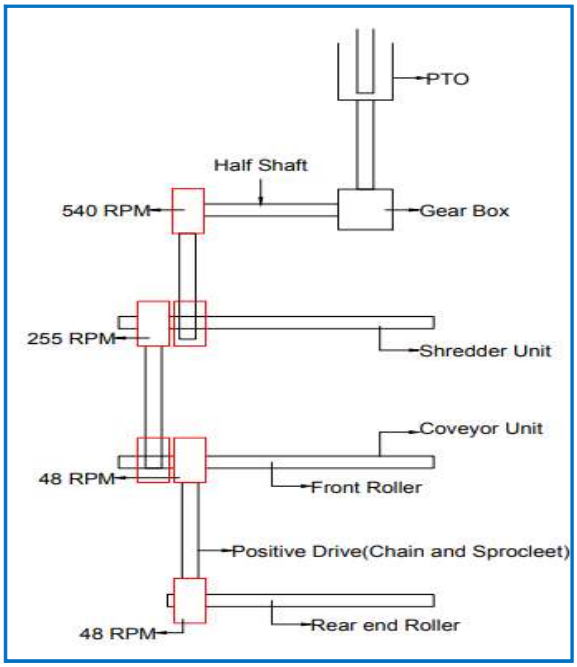

Fig. 7. Power transmission system

Fig. 8. Proto type tractor mounted FYM spreader fabricated under study

% of minimum clod size distribution in the range of less than 10 mm was obtained at 100 mm discharge gate opening and 4 link elements. Smaller manure particles have more surface area resulting in easily availability of nutrients to the microorganisms (Khaffaf 2008, Sahu 2020). This is mainly due to throwing action of the chain links. The bulk density decreased with number of chain links. The lowest bulk density of 0.512 g cm^{-3} was obtained at 75 mm discharge gate opening and 6 no of chain links.

Effect of beating rollers speed of 255 RPM on clod size distribution: The increase shredder 255 RPM and number of chain links, increased the percentage of minimum clod size distribution ranging from less than 10 mm (Fig. 12). The highest percentage of 57.66 % of minimum clod size distribution in the range of less than 10 mm was obtained 4 link elements. Smaller manure particles have more surface area resulting in easily availability of nutrients to the microorganisms (Khaffaf 2008, Sahu 2020). This is mainly due to throwing action of the chain links. 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 4 no of chain links.

Optimized beating rollers speed and beating element length percentage of 0 to 10 mm clod size distribution:

Table 1. Different variables considered for optimization of shredding cum spreader

Treatment	No levels	Particulars
Conveyor speed (RPM)	2	48 and 66
Discharge opening	3	75, 100 and 150 mm clearance
Shredder speed (RPM)	2	180 and 255
Shredder chain length	3	2, 4 and 6 chain links
No of replications		3
Total no of experiments		2×3×2×3×3=108

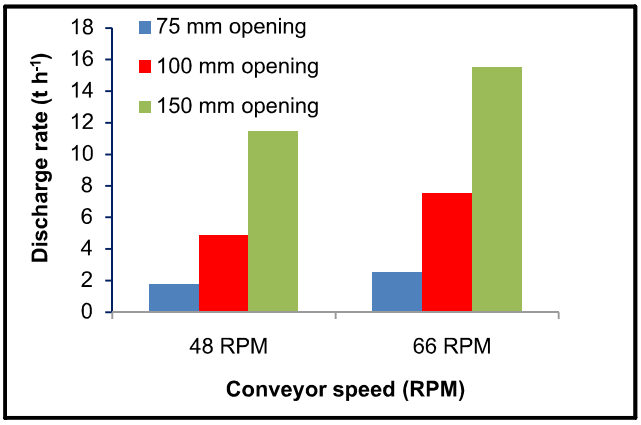

Fig. 9. Averaged is charge rate at different conveyor speed

The shredder speeds 180 RPM and 255 RPM the maximum percentage of small particles found in 255 RPM. This may be due to the high impact force developed due to peripheral velocity (2 m/sec). The data that among the lengths of beating elements 4 links lengths created more percentage of smaller pieces, whereas the 2 links length than 6 link lengths

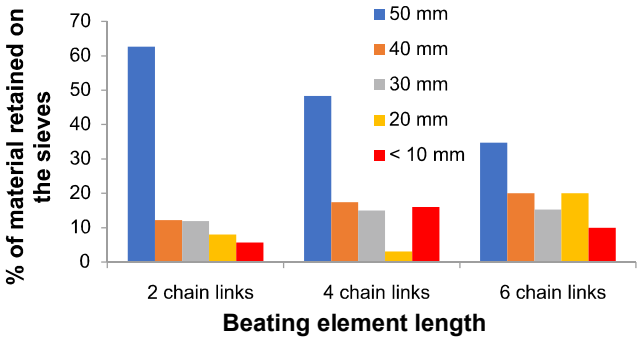

Fig. 10. Clod size distribution at beating roller speed 180 RPM

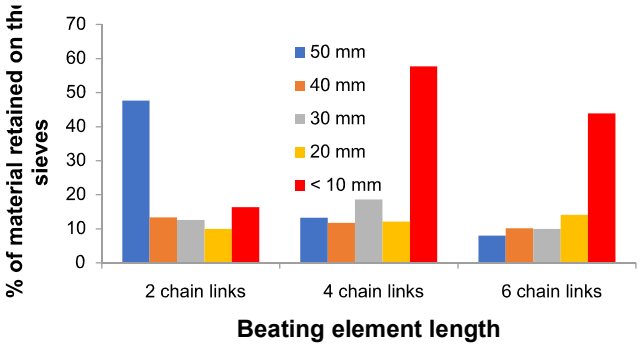

Fig. 11. Clod size distribution at beating roller speed 255 RPM

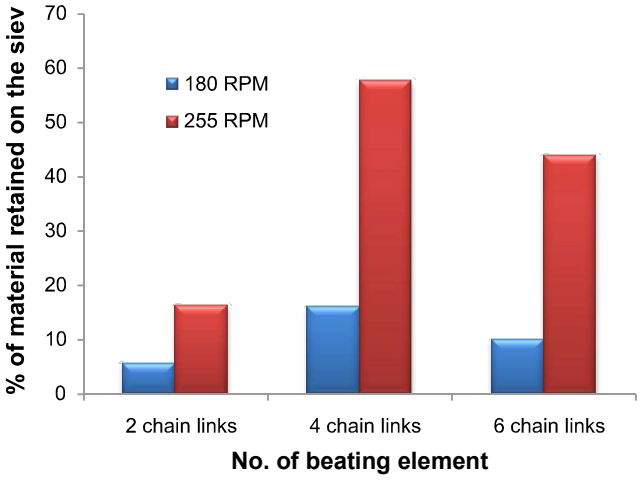

Fig. 12. Best combination for minimum percentage of clod size distribution

larger lumps are retained.

Assessment of width wise uniformity distribution: To determine the width wise uniformity, five small boxes are arranged (open area of 0.019 m^2) along the width line 1800 mm with equal spacing. FYM spreader was run at the conveyor speed of 48 RPM, beating roller speed of 255 RPM with 100 mm discharge gate opening and 4 no chain links of beating elements the shredded and spreader FYM was collected in the boxes. The weight of collected FYM was recorded and experiment was repeated three times. The average weight obtained from each box at 137 grams and 90 grams at bottom of the trailer shank.

CONCLUSION

The developed FYM shredder cum spreading unit was evaluated for optimizing operational parameters and results indicated that Bulk density decreased with increase in beating roller speed from 180 rpm to 255 rpm at FYM conveyor speed 48 RPM and the effect of beating element length also influenced the bulk density and highest percentage 57.66 of clod size distribution ranging from more than 10mm to less than 40mm sieve size of the FYM shredded. The flexibility is provided based on the soil and crop requirement the manure discharge gate will be altered from bottom of conveyor belt.

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