

Design and development of a power tiller operated centrifugal manure spreader with slurry maker for organic farming.

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Abstract

Organic farming is an ecologically sustainable form of agriculture. Organic farming methods are appropriate and adaptable to many types of landuse in any part of Sri Lanka. It could support paddy, vegetable, fruits and some other tree crops, such as Tea, Cinnamon, and Coconut .etc. A major task of organic farming is broadcasting of organic material on the soil surface. Due to high variability of physical characteristics of organic materials, several technical problems can be observed during its handling and application under field conditions. Use of manpower for the application of organic materials is uneconomical due to high labor cost. Therefore power tiller operated centrifugal manure spreader was designed and constructed. This machine was not only useful to broadcast organic materials but also to mix solid organic materials to prepare organic slurry. The designed machine consists of power transmission system with clutch mechanism, slurry making unit and slurry spreading unit. The maximum spreading width in meters, machine discharge rate in L/min and uniformity coefficient of spray distribution, were considered as criteria for comparison of merits and demerits. The test results show that the maximum spreading width, Machine discharge rate and uniformity coefficient of spray distribution, were 6.9m, 49 L/min, and 45%, respectively. The cost of production of the designed centrifugal manure spreader was Rs. 10,000.

Introduction

Organic farming is generally considered more labor intensive than other conventional farming system. The increase in labor requirement has been assessed as ranging from 15% to 40%. But it is an ecologically sustainable form of agriculture. Organic farming methods are appropriate and adoptable for many types of landuse in any part of Sri Lanka. It could support paddy, vegetable, fruits and some other tree crops, such as Tea, Cinnamon, and Coconut .etc. A major operation of organic farming is broadcasting of organic material over the soil. Due to high variability of physical characteristics of organic materials, several technical problems can be observed during its handling and application under field conditions. Use of manpower for the application of organic materials is uneconomical due to high labor cost. As a consequence, the farmer tends to adapt to the labour situation in a way that might not fulfill the demand of the nutrient cycle on the farm.

The introduction of innovative technologies to reduce the labour demand is seen as a way of obtaining more biological fulfilling crop rotations in organic farming. Therefore, the objectives of the present research were to design, develop and evaluate the performance of a power tiller operated centrifugal manure spreader. This machine is not only useful to broadcast organic materials but also to mix the solid organic materials to prepare organic slurry.

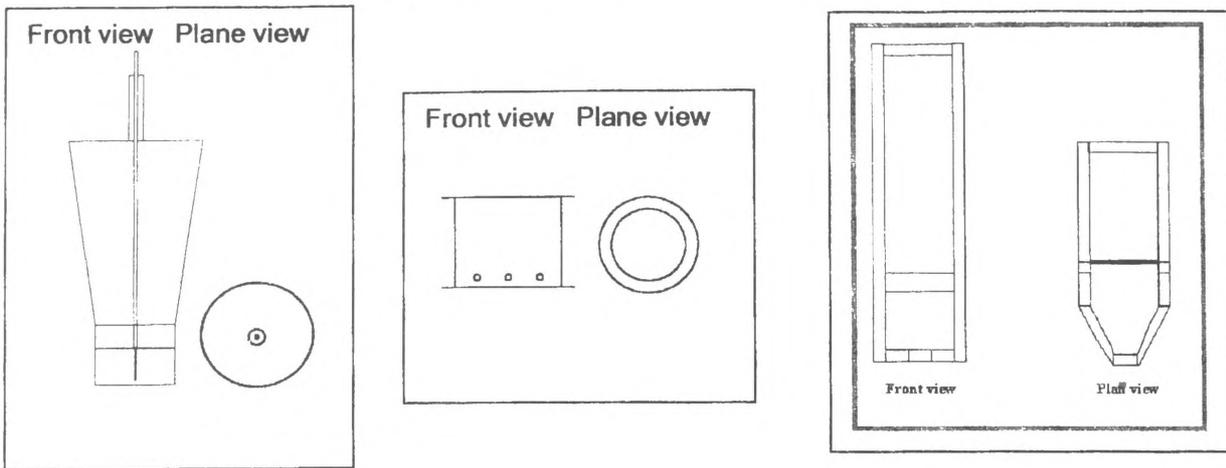
Methodology

Uniformity, width of coverage and slurry distribution pattern are very important factors in designing a slurry spreader. These factors are affected by physical characteristics of organic materials, traveling speed, height of spread from ground and rotational speed of the impeller of the spreader pump.

Centrifugal manure spreader with slurry maker was designed and constructed to attach to the Power Tiller. It can be run on farm roads or wider bunds adjacent to crop field for organic manure applications,

The designed machine consists of Power transmission system with Clutch mechanism, Slurry making unit and Slurry spreading unit.

Figure 01: Final design details of the power tiller operated centrifugal manure spreader:



1. Slurry making unit

2. Slurry broadcast unit

3. Frame

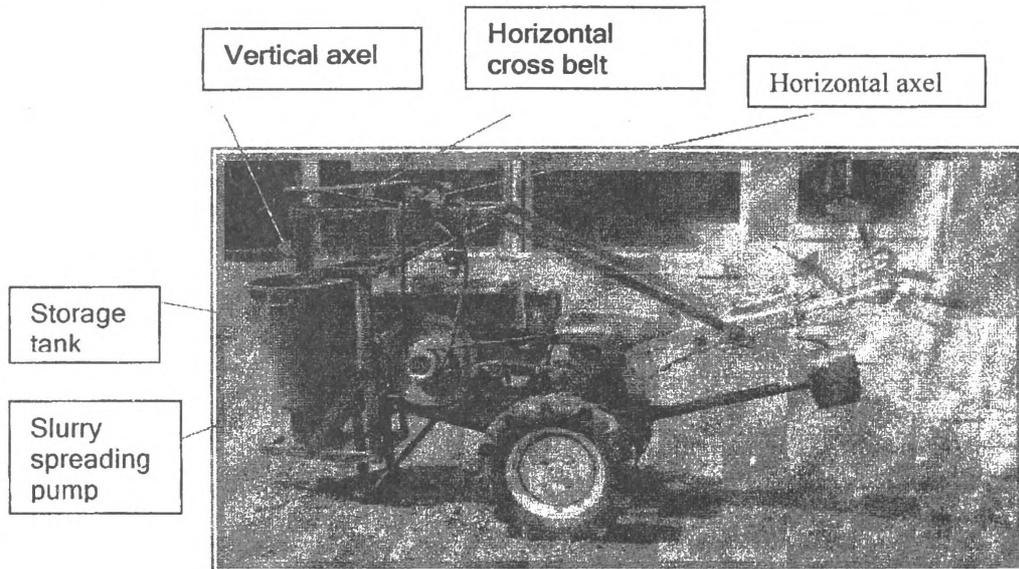


Plate 01: Design of centrifugal manure spreader.

Power transmission unit

It consists of “V” belts and two axels. See Plate 01.

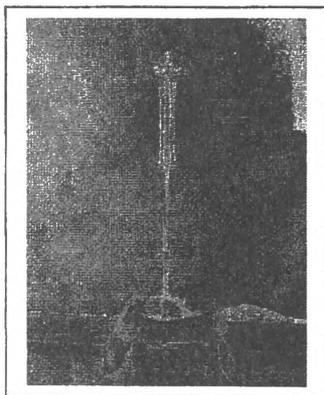


Plate 02: Vertical axel

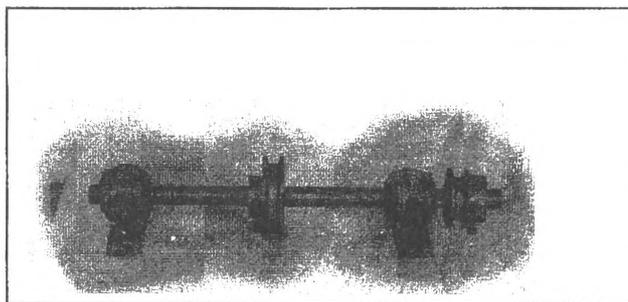


Plate 03: Horizontal axel

The vertical axel consists of upper boll bearing and lower tapered roller bearing. They are fitted tightly in 1014 mm long axel. An impeller was attached to the end of the axel as shown in Plate 02. The horizontal axel consists of adjustable boll bearings and pulleys. It is 480 mm long. Horizontal axel was used to transmit the engine power to an upper stage (see Plate:03). There are two V-belts used in this machine to transmit power with diverting the rotating direction in 90⁰.

Slurry mixing unit: (Slurry making unit)

Slurry mixing unit consist of two main parts.

1. Storage tank
2. Agitator

The storage tank was designed to contain 40 liter of slurry. The agitator is attached to the vertical axel. Its speed is the same as an impeller speed.

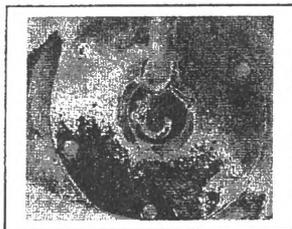


Plate 04: Agitator

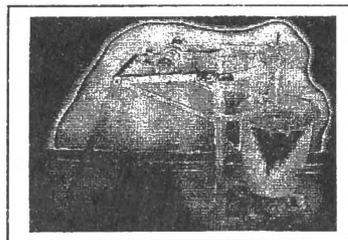


Plate 05: Steel frame

Frame

The developed machine has a strong frame, fabricated by using mild steel angle and flat bars. It was designed according to the dimensions of the power tiller and the pump unit. The width of the frame is 400 mm and the height is 975 mm. All components of the frame were assembled using 10 mm bolts.

Slurry spreading unit

The pump unit is the important part of the machine. It consists of cylindrical casing, impeller, covering plate and rubber seal.

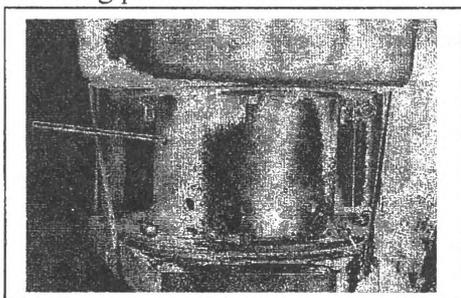


Plate 06: Pump unit

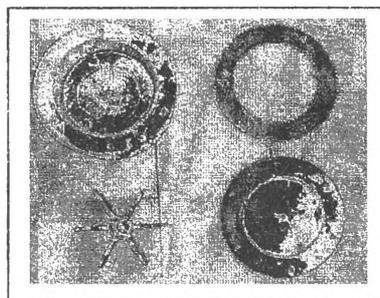


Plate 07: Casing, impeller, covering plate and rubber seal

The designed pump consists of two basic parts; the rotary element or impeller and the stationary element or casing. The impeller was fabricated by fixing 6 blades or vanes to a bush and keyed to the lower end of the vertical shaft (see Plate: 07). The blades were arranged in a circular array around and inlet opening at the centre. The vertical shaft with impeller was supported with a plane bearing. A sealing ring is placed between the cover plate and the pump casing. The lower cover plate formed the base of the pump body to mount the pump to the frame.

Performance testing

Experimental design

The cowdung slurry was prepared and applied to the experiment field plots. The field experiments were arranged in a randomized block design with three replicates. The length of the plot was 15m and the width was 10m.

Discharge rate (L/min), Effective width (m), Travel speed (km/hr), Manure application rate (hr/ha) and Uniformity co-efficient of slurry distribution % were considered as criteria for the evaluation of designed equipment. In addition, cost of production of the designed equipment was calculated.

On the day of measurement, core soil samples was taken for determining the dry bulk density and water content at 3-8 cm depth. Cone penetration resistance was measured using a 'PLAG penetrometer' at 15 randomly selected locations per block. Cow dung from the same dairy farm was used for the experiment. In order to achieve the objectives of the study, four parallel field tests were carried out using four engine speeds with three replicates.

From ASAE Standard S341.2, the uniformity of broadcaster could be evaluated by using trays to

collect slurry from the broadcaster (Plate:08).



Plate 08: Procedure for evaluating the uniformity of slurry broadcaster

Results

The test data for all the treatments were analyzed. The mean values of the data were determined and shown in Table 1.

Table 1: Measured and calculated values of field test data under different test treatments.

Engine speed (r.p.m)	Avg. effective width (m)	Discharge rate (L/min)	Travel speed (km/h)
1250	4.4	51	1.62
1500	6.9	49	2.04
1750	6.8	48	2.30
2000	6.7	43	2.74

The results showed that the Maximum spreading width, Machine discharges rate, Travel speed and Uniformity coefficient of spray distribution, were 6.9m, 49 L/min, 2km/hr and 45%, respectively. The cost of production of the designed centrifugal manure spreader was Rs. 10,000. The field capacity of the designed manure spreader was 11ha/day.

Conclusions

This machine could be used successfully to mix solid organic materials to prepare organic slurry and to incorporate the organic materials into the soil by spreading or injecting. It can be used to apply a wide range of rates and it is adjustable for different fertilizer materials. The field capacity of the designed manure spreader was 11ha/day. The Maximum spreading width, Machine discharges rate and Travel speed were 6.9m, 49 L/min, and 2km/hr, respectively. The cost of production of the designed centrifugal manure spreader was Rs.10,000. The Uniformity coefficient of spray distribution was 45%. A completely uniform distribution will have a CV equal to zero. For good design, broadcaster would have a CV in the range of 20 to 30%. However, under field conditions it is reasonable to achieve the above uniformity coefficient value.

References

- Corrin, G. (1995). Handbook on composting and the bio-dynamic preparations. Biodynamic Agricultural Association, UK.
- Lena, R, Ararso, E. (2005). Performance of slurry Injectors compared with band spreading on three Swedish soils with Ley, Biosystem Engineering, p 107-118, Silsoe Research Institute, on line at WWW.sciencedirect.com.
- Philbrick, J, Philbrick, H. (1988). Gardening for health and nutrition: an introduction to the method of biodynamic gardening. Anthroposophic Press, USA.
- Richard, T, S. (2002). Organic farming, Sustaining Earth and people. Centre for Organic Agri.development, Kalaniya, Sri Lanka.
- Sorensen, C, G, Madsen N, A, Jacobsen. B, H, (2005), Organic Farming Scenarios: Operational Analysis and costs of implementing Innovative Technologies. Silsoe Research Institute, on line at WWW.sciencedirect.com.
- Villelle. S, Cointault. F, Piron. E, Chopinet, B, Centrifugal Spreading: An Analytical model for the Motion of Fertiliser Particles on a Spinning Disc. Silsoe Research Institute, on line at WWW.sciencedirect.com.