

Performance Evaluation of Bullock Drawn Farm Yard Manure Spreader

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Abstract - *Application of organic manure in the field is an important input operation in the crop production. A bullock drawn manure spreader was designed and developed with a view to apply farmyard manure uniformly at desired application rate in the field. The performance of the manure spreader was evaluated for spreading of most commonly used organic manure i.e. farm yard manure. The draft requirement of the manure spreader at no load condition, partial load condition and at full load condition was found to be 78, 227 and 294 N respectively. The performance of the spreader was evaluated at four different width of delivery slot of manure box, ranging between 50-200 mm. The application rate, manure delivery rate, swath and uniformity of distribution were determined. The study revealed that application rate increased with increase in area of opening of delivery slot and was found to be varying between 6.23 – 13.35 t/ha. The manure delivery rate was found to be varying between 0.38-0.83 kg per second. The machine worked satisfactorily and achieved uniform application rate of farm yard manure in the field with reduced human drudgery.*

Keywords: *Farm yard manure, Manure spreader, Evaluation, Human drudgery.*

1. INTRODUCTION

Crops extract annually large quantity of plant nutrients from soil, leaving the soils in plant nutrient deficit. Therefore, the soils of India need to be replenished with plant nutrients regularly. Much of the plant nutrients, thus removed can be restored through application of organic manures. Application of organic manure in the field was the only way, available to the farmers for replenishment of the soil, before introduction of chemical fertilizers in India. Manure is a valuable and renewable resource, used as nourishment in crop production and is considered as the eco- friendly bio-fertilizer for the highly polluted modern era (Reddy et.al., 2014). In India, farm yard manure is used as a main source of organic manure. Total Farm yard manure available in the country is approximately 1200 million ton including availability of 268 MT dung from livestock and 5 MT poultry droppings for bio-methanation to produce biogas and manure of high quality. 50% Farm yard manure is used to improve soil fertility and remaining is used for fuel (Singh et. al., 2014). In India, Farm yard manure is applied using manual broadcasting

method and bullock -carts /tractor trailers resulting in human drudgery, more time per unit area and loss of nutrients with poor application uniformity and wide variation in the application rate (Singh et. al., 2013). In view of the above, suitable technological intervention was required, for mechanization of manure spreading operation for large number of small and marginal farmers of the country, who essentially rely on draught animals. Therefore, a bullock drawn manure spreader was developed and evaluated.

2. MATERIALS AND METHODS

A bullock drawn Farmyard manure spreader was designed and developed at Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad. The machine designed and developed, was evaluated for uniform application of farm yard manure in the field at different manure delivery rates and application rates. The details of components of developed machine were as follows:

Frame- The frame of the developed manure spreader was made of angle iron of 37x37x2mm. The length of the frame was 950 mm and it was 400 mm wide. The other components of manure spreader, like manure box, feeding drum etc were mounted on the frame. Two wheels (pneumatic tyres) were provided for transportation of manure spreader in the center of frame. A third wheel was also provided at the rear of the frame to act as castor wheel.

Manure box- The manure spreader developed, consisted of a manure box, 600 mm in length and 600 mm wide of square cross section. The box was fabricated of 16 gauge MS sheet. To facilitate flow of manure freely from box, the box has been given a trapezoidal shape with slanting sides. The maximum handling capacity of the manure box was 75 kg of manure.

Feeding drum- A feeding drum was provided below the box; 450 mm in length and 260 mm in diameter .The drum receives the manure from box and drops it over an auger. The drum has spokes all around its periphery to facilitate easy movement of the manure and crushing of small lumps. The power to drum was given directly from ground wheel through chain and sprocket.

Auger- A screw auger has been provided below the drum for distribution of manure to both sides equally. The auger fixed below the drum had a diametrical pitch of 260 mm and 850 mm in length. The power to auger was given directly from ground wheel through chain and sprocket. This auger spread the manure.

Sheet sliding mechanism- A sheet sliding mechanism was provided between manure box and feeding drum, to control the manure delivery rate to feeding drum. It has a screw mechanism to slide a sheet for allowing estimated quantity of manure to drop. Thus by increasing /decreasing the opening width through sliding sheet, the manure delivery rate was controlled to obtain desired application rate in the field.

2.1 Performance evaluation of manure spreader

The developed manure spreader was evaluated in the field for determination of draft, manure delivery rate, application rate and uniformity of distribution with a pair of bullock. The body weight of the pair of bullock, used in the study was 849 kg. The manure spreader was filled with the farm yard manure. The bulk density of the manure used during the testing was 345.5 kg /m³ and manure clod size ranged from 15-85 mm with mean manure clod diameter of 34 mm. Set of sieve of appropriate sizes were used to determine mean manure clod diameter of farm yard manure (test material) before the test. The draft and speed of operation of the manure spreader was recorded under different conditions of load viz. no load, partial load and full load conditions and have been reported in Table 1. Manure collection boxes of 500 g capacity were placed on the ground at an interval of 400-600 mm, to determine the coefficient of variation of uniformity of manure application. To achieve different manure delivery rates, the opening area of the delivery slot of the spreader was varied. Boxes filled with manure were collected and weighed with and without manure. Width of application of manure was measured in the field using metric tape. The weight of Manure of 10 m length in the direction of line of travel was determined using weighing balance. Time of travel, required by the manure spreader for 10 m distance was recorded to determine manure delivery rate of the machine (quantity of manure delivered in unit time). By substituting the manure delivery rate in equation (1), the manure application rate (AR) was determined. The coefficients of variation of uniformity was determined by using the equation (2)

$$AR = \frac{Q \times 10000}{W \times V} \dots\dots(1)$$

$$CV = 100 \times \left[\frac{SD \left(\frac{\sum x}{N} \right)}{\dots\dots} \right] \dots\dots (2)$$

Where, AR = application rate kg ha⁻¹; Q= manure delivery rate, kg s⁻¹; W = width of application, m; V = forward travel speed, ms⁻¹; C V= coefficient of variation of uniformity for manure distribution, %; SD = standard deviation of a set of observations, $\sum x$ = sum of set of observations, g ; and N = total number of observations.

The fixed and variable costs for developed bullock drawn manure spreader were calculated. Cost economics of developed machine was computed along with labor requirement and reported in Table 2.

3. RESULTS AND DISCUSSIONS:

Draft and power requirement of the manure spreader

The draft requirement of the developed manure spreader under no load, partial load (auger and feeding drum disengaged) and full load condition (auger and feeding drum engaged) at different width of delivery slot is stated in Table 1. The average draft requirement of the spreader at no load condition was found to be 78 N. The draft requirement under partial load condition and full load condition was found to be 227 and 294 N respectively. The power required by the spreader was 171.9 watts at partial load condition and 214 watts at full load condition. The power requirement of the manure spreader increased with the engagement of the auger and feeding drum, obviously due to increase in power requirement to run spreading and feeding units and consequent increase in motion resistance between ground wheel and ground. The draft exerted by the manure spreader was well within the draft capacity of the pair of bullock i e 10% draft of the body weight (Anonymous. 2003). Since, draft is a limiting factor for animal operated machines, therefore utmost care is required to be exercised, so that it do not exceed the optimum limit.

Variation in manure delivery rate

The manure delivery rate of the manure spreader at different width of delivery slot is given in Table 2. The manure delivery rate varied with variation in size of opening and ranged between 0.38 to 0.83 kg per second with the increase in opening area. The increase in manure delivery rate with increase in opening area of delivery slot was due to availability of more area, allowing increased quantity of manure to pass through.

Table 1 Draft and power requirement of manure spreader in the field.

Sl No.	Draft (N)	Speed (m/s)	Power (kw)
1	No load condition		
	78	0.75	57.74
2	Partial load condition (With auger and drum disengaged)		
	227	0.74	171.93
3	Full load condition (Auger and drum engaged)		
	Width of opening (mm)		
50	264	0.73	198.93
100	280	0.73	208.26
150	306	0.70	218.95
200	328	0.70	233.24
Av	294	0.71	214.84
Power requirement of auger	-	-	42.9

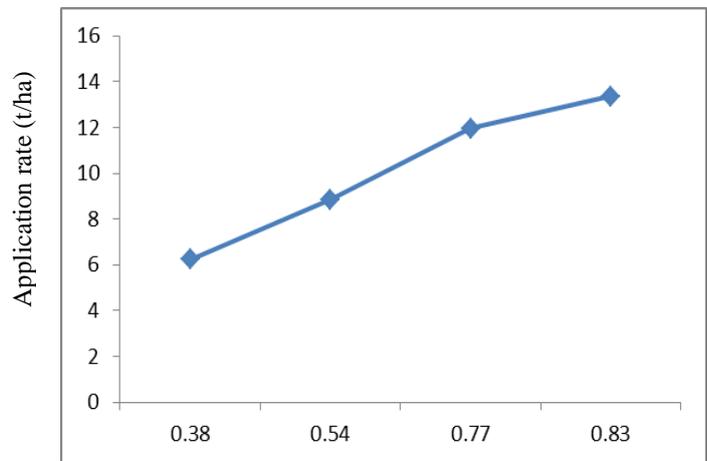


Figure 1 Manure application rate at different manure delivery rate

Table 2. Field Performance of farm yard manure spreader.

Width of opening (mm)	Average Manure delivery rate (kg/sec)	Average Application rate (t/ha)	Coefficient of uniformity (%)	Average width of application (m)	Average Actual field capacity (ha/h)	Cost of operation (Rs/ha)	Labor requirement (mh/ha)
50	0.38	6.23	76.58	0.84	0.129	734.7	15.46
100	0.54	8.84	79.52	0.88	0.120	752.2	15.82
150	0.77	12.35	81.74	0.88	0.10	871.4	18.33
200	0.83	13.35	84.38	0.90	0.097	938.63	19.75

Moisture content 25-30%

Co-efficient of uniformity

Variation in application rate

The application rate is a very important parameter for application of desired quantity of manure in the field, suiting to the requirement of the crop. The application rate increased with increase in the size of delivery slot. The manure application rate increased from 6.23 to 13.35 t/ha with increase in size of delivery slot. The application rate obtained with manure spreader at different width of delivery slot is given in Table 2. Field performance of manure spreader in terms of manure application rate at different manure delivery rate is shown in Fig 1. The relation between manure delivery rate and application rate was found to be linear and may be represented by equation $Y = mx + c$.

The coefficient of uniformity of the manure spreader also varied with variation in manure delivery rate. The coefficient of variation decreased from 23.42 % to 15.62 % with increase in manure delivery rate from 0.38 kg to 0.83 kg/s. The developed spreader achieved the coefficient of variation close to 20% in longitudinal direction to the speed of operation with increase in manure delivery rate which is an upper acceptable boundary for the application of granular fertilizers (Alam et al., 2002). It showed that the developed machine gave the satisfactory uniformity of manure application. The average swath at different manure delivery rate varied between 0.84-0.90 m. The average swath at different manure delivery rates varied arbitrarily and shown no definite pattern.

Cost of operation and labor requirement

The cost of operation of manure spreading operation at different manure delivery rate with manure spreader is presented in Table 2. Manual method of spreading manure is the widely practiced method in India with poor application uniformity and high human drudgery. The cost of operation was found to be varying between Rs 734-938 per ha with manure spreader on all the four width of opening tested in the study. Similarly, the labor requirement was found to be varying between 15.46-19.75 mh/ha.

CONCLUSION

The developed manure spreader was tested under actual field condition. The draft requirement, being a limiting factor, was found to be well within the draftability range of the pair of bullock. The average draft requirement at full load condition was found to be 294 N. The manure delivery rate and application rate increased with increase in area of opening and ranged between 0.38-0.83 kg/s and 6.23-13.35 t/ha respectively. The coefficient of uniformity of distribution was found to be ranging between 76.58-84.83%. The coefficient of variation of uniformity of manure distribution was close to 20%. The field capacity of machine varied between 0.97- 0.129 ha/h. The machine worked satisfactorily and achieved uniform application rate of farm yard manure in the field with reduced human drudgery.

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