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Performance evaluation of tractor drawn FYM applicator cum seed drill for mung bean crop

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Abstract
The purpose of this study was to evaluate the performance of a tractor-drawn FYM cum seed drill for planting mung bean crops. On vertisol soil, the field tests were conducted. T1-100 per cent RDN through manual broadcasting of seeds and FYM, T2-100 per cent RDN using FYM applicator cum seeed drill, were the treatments. FYM applicator cum seed drill has the seed rate of 24.18 kg/ha. With a seed yield of 8.5 q/ha, mung bean sowing by tractor-drawn FYM applicator with 100 per cent RDN performed better than the broadcasting approach. Mung bean plants sown using tractor-drawn FYM applicator cum seed produced increased yields, plant height, population, and pods per plant. The machine's operation cost was found to be Rs. 1,294 per hectare. Farmers were using traditional methods to apply FYM. This strategy is ineffective for distributing FYM evenly in the field. A tractor-drawn FYM applicator cum seed drill can apply FYM and seeds at the same time.

Keywords: FYM, broadcasting, seed cum fertilizer drill, RDN

Introduction

Organic agriculture is an ecologically demanding agricultural strategy that is gaining popularity worldwide as the need for sustainability increases (Willer *et al.*, 2019) [8]. According to the "World of Organic Agriculture 2018" report, India accounts for 30% of all organic producers worldwide. Organic manure can fulfil the nutritional requirements of crops while also encouraging soil macro and micro flora activity (Sharma, 2005) [6]. Organic farming is based on the use of minimal off-farm inputs and management strategies that restore, maintain, and improve ecological equilibrium. In Chhattisgarh, farmers apply FYM as a biofertilizer. An increase in farmyard inputs in the field increases crop yield by maintaining soil quality (Mahanta *et al.*, 2013) [3]. It functions as a mixed fertilizer. FYM improves the physical, chemical, and biological characteristics of the soil.

India is the world's largest producer and consumer of pulses, accounting for about 25% to 28% of global output. Pulses are the cheapest source of protein, accounting for roughly 14% of total protein in the Indian diet on average (Singh *et al.*, 2015) [7]. The application of vermicompost and FYM improved mung bean yield characteristics, yield, and dry matter output significantly (Jat *et al.*, 2012) [1]. Mung bean nutrient content is altered by vermicompost, resulting in improved mung bean yield and quality (Pashanasi *et al.*, 1996) [4].

The farmers are applying FYM by the conventional manner. They used to transfer FYM from the compost pit to the field, where it was stacked. The spreading of the piled FYM is done manually with a spade, followed by tillage and seeding operations. This method is not suitable for the uniform distribution of FYM on the field. In rural areas, seeding operation is also done manually by broadcasting, dibbling, and seed dropping behind the plough. This traditional method of sowing involves tedious work, which causes fatigue and backache to the operator (Bamgboye and Mofolasayo, 2006) [1].

Tractor drawn FYM applicator cum seed drill is a machine that applies FYM in band form and simultaneously, seeding operation is done by planter unit (Sahu *et al.*, 2020) [5]. Considering the above points, feasibility testing of tractor drawn FYM applicator cum seed drill was done at IGKV, Raipur fields for 2 treatment. The comparison was made between seed cum fertilizer drill and conventional method of sowing and FYM application (broadcasting). FYM applicator cum seed drill not only conserves the time and energy, but also reduces the cost of cultivation, improves soil environment for better crop yield.

Materials and Methods

Laboratory Testing

The machine was put to the test in the lab for determning mung bean application rates in kilogrammes per hectare. The "Hum-16" variety of mung bean seed was used to calibrate the seed drills. The calibration test procedure as per IS (Indian Standard) test code 6316:1993 is as follows.

i. The nominal width of coverage of the seed drill was calculated by the below given formula

$$W = \frac{Nd}{100}$$

Where,
W = Nominal width, m;
N = Number of furrow openers; and
D = Distance between two adjacent furrow openers, cm

ii. Circumference of the driving wheel was measured by the formula given below

$$L = \frac{\pi d}{100}$$

Where,
L = Circumference of the driving wheel, m;and
D = Diameter of the driving wheel, cm.

iii. Area covered in one revolution of driving wheel was calculated by the formula given below

$$A = WL$$

Where,
A = Area covered in one revolution of driving wheel, m^2;
L = Circumference of the driving wheel, m; and
W = Nominal width, m.

iv. The number of revolutions required to cover 1/25 ha of land was determined. The area covered in one revolution of the driving wheel was divided by 400 m^2.

v. By jacking up the drill, the drive wheel was made free to rotate. The driving wheel was marked so that the revolutions could be easily counted. Under each boot or furrow opener, there are bags or canisters. For the test, the seed hopper was filled with chosen seed and the rate control setting was adjusted.

vi The driving wheel was practiced to rotate for fixed number of rotations calculated above, the weight of the seed which was dropped in the bags or containers under each furrow opener were measured.

vii Calculated the seed dropped in kg /ha and the data were noted down.

viii Above procedure was repeated till the required seed rate was obtained.

A polytene sheet with a surface area of 25 × 6 m^2 was laid on the ground to test the application rate of FYM at various forward speeds. On this polythene sheet, the FYM applicator was run and FYM was dropped on the polytene sheet. The dropped FYM was collected and weighted to estimate the FYM application rate at various forward speeds and orifice openings. After completion of the calibration test the field experiments were conducted with the same seed and FYM. To evaluate the performance of the machine the following parameters has been considered. During the month of March 2021, field experiments for mung bean seed were done on the experimental farm of IGKV, Raipur. Two passes of the cultivator and one pass of the rotavator were used to finish the field preparation. The machine was powered by a Massey Ferguson 241 tractor. The 70 ×72 m^2 field was subdivided into sub plots of 32 ×30 m^2. For the machine's performance, two treatments were used. In the field, treatment was given at random. Because the study used a mung bean crop, the spacing between tines was adjusted to 45 cm.

Fig 1: Sowing of the mung bean by FYM cum seed drill

Fig 2: Tractor drawn FYM applicator cum seed drill

1. Soil parameters, viz moisture content and bulk density of the soil

a) Moisture content of the soil

To determine the moisture content, soil samples were taken up to the full depth of core sampler i.e. 115 mm and weighed. Moisture content was determined by oven dry method i.e., keeping in oven for 24 h at 105 °C.

$$M_{db} = \frac{W_1 - W_2}{W_2}$$

Where,
M_{db} = Moisture content in dry basis, %;

W_1 = Initial weight of the soil sample, g; and
W_2 = Borne dry weight of the soil sample, g.

b) Bulk density of the soil

The bulk density of soil plays an important role in the material handling and evaluating the performance of the machinery. The bulk density was found out by measuring the volume and weight of the soil sample. The soil samples were collected by using the core cutter method in the experimental field. The following relationship was used for calculating it

$$\rho b = \frac{W_m}{\frac{\pi d^4}{4} \times L}$$

Where,
ρb = Bulk density, kg/m^3;
Wm = Weight of the sample, kg;
d = Diameter the measuring cylinder, m; and
L = Length of the measuring cylinder, m.

2. Machine and operational parameters include average operating time, speed of operation, effective field capacity, field efficiency

a) Speed of operation

To establish the speed of operation, a 25-meter run length was marked and the machine was ran in that length. A stop watch was used to record the time it took the machine to complete the indicated run, allowing the speed of travel to be calculated in kilometres per hour.

b) Effective field capacity

The actual area covered by the implement, based on its total time utilised and width, was used to determine its effective field capacity. The following relationship was used to evaluate effective field capacity.

$$\text{Effective Field capacity (ha/h)} = \frac{\text{E (ha)}}{\text{T (h)}}$$

Where,
E = Effective area covered, ha; and
T = Time required to cover the area, h.

c) Field efficiency

Field efficiency was calculated using the following formula by effective and theoretical field capacity

$$\text{Field efficiency (\%)} = \frac{\text{EFC}}{\text{TFC}} \times 100$$

Where,
FE = Field efficiency (%);
EFC = Effective field capacity (ha/h); and
TFC = Theoretical field capacity (ha/h).
Theoretical field capacity was calculated by the following formula

$$\text{Theoretical Field capacity (ha/h)} = \frac{W \times S}{10}$$

Where,
W = Effective width of implement, m; and
S = Speed of operation, km/h.

3. Sowing parameters include seed rate, depth of sowing and seed to seed spacing

a) Seed rate

The seed rate was calculated by weighing the seed prior to and after the sowing procedure. The seed rate was calculated by subtracting the end weight of seed from the initial weight of seed, and the results were represented in kilogrammes per hectare.

b) Depth of sowing

A steel scale of 0.3 m was used to determine the depth of seed sowing. For each figure, the mean of twenty random observations was derived to indicate the depth of sowing.

c) Seed to seed spacing

After sowing, a steel scale with a length of 0.30 m was used to measure seed to seed spacing. The soil was carefully removed from at least five random locations in ten rows without damaging the seeds, and the mean was calculated to indicate seed to seed spacing.

4. Crop parameters include average plant population, plant height**, no. of pods per plant, pod yield**

a) Average plant population

The average plant population was determined by counting the number of plants per square metre at five random places of the various treatments and the mean value was determined to represent the average plant population.

b) Plant height

At five randomly selected regions of varied treatments, plant height was measured from the base of the stem to the tip of the topmost leaf. The plant height was measured at 15, 30, 45, and 60 DAS intervals. The average height of the plants was computed and given in centimetres.

c) Number of pods per plant

The pods from five randomly selected plants of various treatments were separated and total pods was counted and average number of pods per plant was recorded.

d) Seed yield

Seed yield was determined from 1 m^2 area. Five random observations were taken from each field and thoroughly dried under sun. After completion of sun drying, the seeds are separated from plants and the weight of seeds were recorded and then converted to kg/ ha.

5. Cost analysis which includes fixed cost and operating cost were calculated

Fixed cost:

a) Annual depreciation (by straight method)

$$D = \frac{C-S}{L}$$

Where,

D=Depreciation/year;
C = Initial cost;
S = Scrap value = $\frac{C}{10}$; and
L = Life of machine in years.

b) Interest investment at 10 % per annum

$$I = \frac{C+S}{2} \times \frac{R}{100}$$

Where,
I = Annual Interest, /year; and
R = Rate of interest, % per annum.

c) Shelter/ housing cost
Housing costs were estimated based on the current rate in the area and were often set at 1% of the machine's initial cost per year (International Standard 9164: 1979).

d) Taxes
Taxes were estimated based on actual taxes paid every year, but were roughly approximated as 1% of the machine's initial cost per year. (International Standard 9164: 1979).

e) Insurance
The insurance charge was calculated based on the actual payment to the insurance company, however it was usually calculated at 1% of the machine's initial cost. (International Standard 9164: 1979).

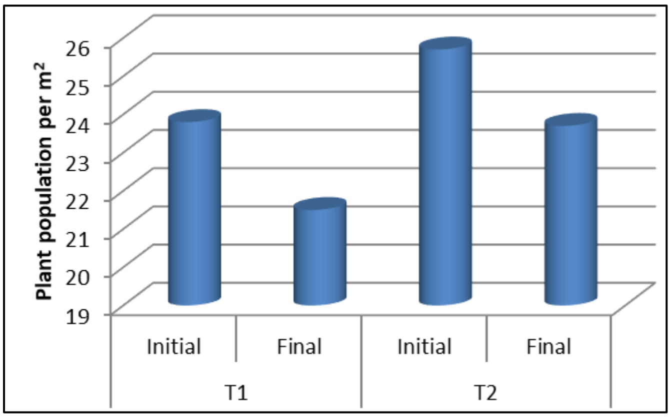
Variable cost
a) Fuel cost
The amount of fuel consumed is determined by the size of the power unit, the load factor, and the operating conditions. The cost of fuel is estimated based on the amount of fuel consumed during operation. (International Standard 9164: 1979)

b) Lubricants
Charges for lubricants were calculated on lubricants' actual consumption, but approximately 20 % of the total fuel cost are approximately lubricant charges.

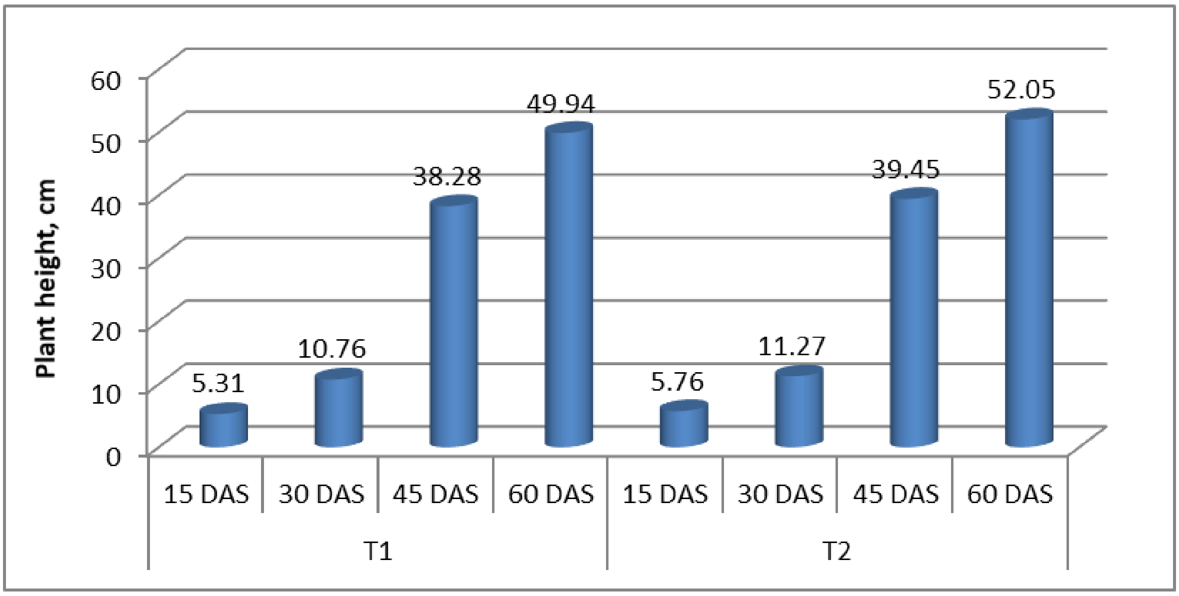
c) Repair and maintenance
Repair and maintenance per annum cost were considered at 10 per cent of the initial cost.

d) Wage of operator
The wage of an operator was 300.00 for 8 hours; So that cost for four operators is 150 Rs per hour.

Result and Discussion
Seed rates for the mung bean seed observed was 24.18 kg/ha, for the FYM applicator cum seed drill. The recommended seed rate for ground nut was 24-28 kg/ha. The calibrated values were just approaching to the recommended value. Therefore these values of seed rate were recommended for mung bean crop.
Soil bulk density at the time of sowing was found to be 1570.99 kg/m^3 with a moisture content of soil at the time of sowing of 24.11 % (db).
Theoretical field capacity for the machine was calculated as 0.85 ha/h. However, effective field capacity of the machine was calculated as 0.59 ha/h. The field efficiency for the machine was found 69.4 per cent.
The average seed depth of the seed sown by FYM applicator cum seed drill was 4.81 cm while for the broadcasting seed depth was 0 cm. The average depth of FYM placement was 5.5 cm through FYM applicator cum seed drill.
The average spacing of the seeds sown by FYM applicator cum seed drill was found to be 9.5 cm. In the method of broadcasting there was uneven distribution of the seeds as well as the FYM. The seed spacing varied from 3.5-15.2 cm.

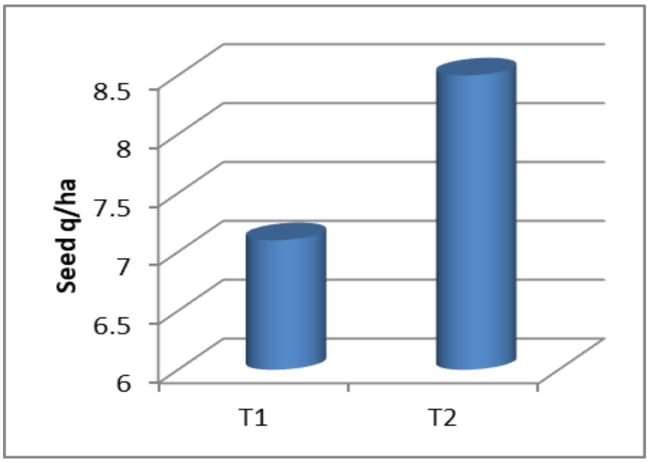


Plant population per meter^2

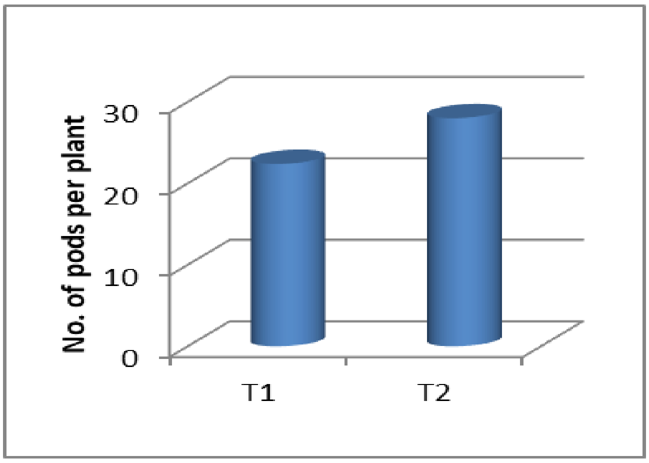


Plant height at different DAS, cm

Average plant population per m^2 of T1 at initial stage and at the time of harvest was found to be 23.8 and 21.5 respectively. Average plant population per m^2 of T2 at initial stage and at the time of harvest was found to be 25.7 and 23.7 respectively. Average plant height in T1 at 15, 30, 45, 60 DAS was found to be 5.31, 10.76, 38.28, 49.94 cm. Average plant height in T2 at 15, 30, 45, 60 DAS was found to be 5.76, 11.27, 39.45, 52.05 cm. Average number of pods in T1 and T2 was 23.29 and 28.02. Seed yield at T1 and T2 was found to be 7.1 and 8.5 q/ha.



Seed yield q/ha



No. of pods per plants

The cost of operation of FYM applicator cum seed dill was ₹ 765.72 /h and that operational cost was ₹ 1294 /ha.

Conclusion

1. It was observed that the performance of tractor drawn FYM applicator cum seed drill was satisfactory for mung bean crop. The field capacity of the machine was found to 0.59 ha/h.
2. Mung bean sown through tractor drawn FYM applicator cum seed showed higher yield, plant height, plant population and no. of pods per plant.
3. The cost of operation of machine was found to be 765.72 Rs/h and 1294 Rs/ha.

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