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Performance Evaluation of Three Row Animal Drawn Multi Crop Planter cum Herbicide Applicator

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ABSTRACT

A three row animal drawn multi crop planter cum herbicide applicator was developed at Swami Vivekanand College of Agricultural Engineering and Technology and Research Station, IGKV, Raipur. laboratory tests and field trials were conducted to evaluate the performance of developed machine. Three crops namely soybean, green gram and maize were selected to conduct the performance evaluation of the machine. The tests were conducted to evaluate the machine on the basis of seed rate, nozzle discharge rate, pressure developed in sprayer boom, speed of operation, field capacity, field efficiency, draft requirement and power requirement. Cost of operation was also calculated. The average seed rates for soybean, green gram and fodder maize were found out to be 77.85 kg/ha, 17.66 kg/ha and 42.86 kg/ha respectively. The average draft requirement of the implement was 440.92 N. The average speed of operation was 1.80 km/h. The average power required was 0.22 kW. The average field capacity and mean field efficiency was 0.143 ha/h and 73.8 per cent respectively. The average discharge of boom was 965.2 ml/min. The average pressure developed in the boom was 254.97 kPa. The average cost of operation was determined as 543/ha.

Key words: Multi crop planter, draught animal, sprayer, herbicide applicator, field efficiency

I. INTRODUCTION

Farm mechanization has played a significant role in timely farm operations, reduction of losses and reduction of cost of operations and thereby increasing agricultural productivity. Large population Indian farmers are those with small and marginal land holdings. Usage of heavy farm machinery is neither feasible nor economical for these farmers. Hence they are mainly dependent on manual power and animal power as the source of farm power. Using these power sources, agricultural operations are carried out using traditional methods. These methods are inefficient, labour intensive and very time consuming and results in less productivity when compared to

mechanized farming techniques. This problem can be tackled by developing machines which can be operated by making efficient use of man power and animal power, resulting in conserving time and increasing productivity, while keeping comfort of the operator in mind. Bullocks are one of the cheapest sources of animal power. Bullocks can develop draught equivalent of $1/5^{th}$ to $1/6^{th}$ of their body weight (Devnani, 1991). In Chhattisgarh, nondescript breed of bullocks (543 kg/pair) are commonly used which can generated 14 per cent of their body weight i.e. 76 kg (Dave and Mukherjee, 2001).

Planting is one of the most significant operations in agriculture. Crop yield, cropping reliability, cropping frequency etc. depends on the uniform placement of seeds at an adequate depth. . A multi crop planter is designed to fulfill the requirements of different row to row spacing, seed to seed spacing and depth of sowing of different crops. Weeds are leading cause of crop damage in India. Weeds cause 10-80 per cent crop yield losses, deteriorate quality of product causing health problems and damage to the environment (Rao *et al.* 2015). India suffers yearly loss of USD 11 billion due to weeds alone in 10 major crops of India viz. groundnut, soybean, green gram, pearl millet, maize, sorghum, sesame, mustard, direct seeded rice, wheat and transplanted rice (Gharde *et al.* 2018).

Considering these points a three row animal drawn multi crop planter cum herbicide applicator was developed to perform the two agricultural operations planting and pre-emergence herbicide application simultaneously. This paper presents the performance evaluation study of above said developed machine.

II. MATERIALS AND METHODS

This study was conducted in the year 2018 at Department of Farm Machinery and Power Engineering, Swami Vivekananda College of Agricultural Engineering & Technology and Research Station, IGKV, Raipur. The different component of the implement were fabricated and assembled in the institute's workshop. The developed machine was tested in laboratory and in field as per the standard procedure by using IS 6316: 1993 and IS 10134: 1994 test codes.

A. Evaluation of the developed machine

The developed machine was evaluated on the basis of parameters such as seed rate, nozzle discharge rate, pressure developed in sprayer boom, speed of operation, field capacity, field efficiency, draft requirement, power requirement and cost of operation.

B. Seed rate

Calibration was done to set the developed multi-crop planter to achieve approximate seed rate recommended for selected crops. Vertical rotors were selected as per the requirements of the selected crops. The selected vertical rotor were then tested for calibration of selected seeds with 8 seed box exposure scale with hopper of full fill, 3/4 fill and 1/2 fill capacity. Readings were taken for different exposure scales for different hopper capacities and the value observed were then compared. The values nearest to the recommended seed rate of the crops were selected for further analysis.

C. Nozzle discharge rate

Nozzle discharge was calculated for forward speed of 1.75 km/h. The planter cum sprayer was jacked up and $3/4^{th}$ volume of the sprayer tanks were filled with water. Polythene bags were attached to the sprayer nozzles such that any discharge was collected in the polythene bags. The ground wheel was rotated at 20 rpm speed (equivalent to 1.75 km/h forward speed for 470 mm diameter of ground wheel) the discharge was calculated by measuring the water collected per minute from each nozzle individually.

D. Pressure developed in boom

The pressure generated in boom was calculated using a pressure gauge. The recommended pressure for the proper operation of sprayer is 1 - 4 kg/cm^2 or 98.07 - 392.27 kPa.

E. Speed of operation

For calculating the speed of operation, two poles were used to mark 15 m length. Time required to cover this distance was recorded using a stopwatch. The time was recorded 5 times to find out the average speed of operation.

F. Theoretical field capacity

It is the rate of field coverage in hectare per hour when the implement is working at its 100 per cent rated speed and width. It was calculated by measuring the nominal width of the developed implement, taking the rated speed and putting up the values in following formula (Bainer *et al.*, 1987)

$$TFC = \frac{W \times S}{10}$$

Where,
TFC = Theoretical field capacity, ha/h
W = Width of operation, m
S = Speed of operation, km/h

G. Actual field capacity

Actual field capacity was measured for an area of 21 x 19 m^2 i.e. 0.0399 ha. It was calculated by recording the time to cover the total selected area including the loss of time in turning, filling of hopper, filling of sprayer tanks etc. The actual field capacity or the effective field capacity was calculated by using following formula (Bainer *et al.*, 1987)

$$AFC = \frac{A}{T}$$

Where,
AFC = Actual field capacity, ha/h
A = Area covered, ha
T = Time taken, h

H. Field efficiency

It is the ratio of actual field capacity to theoretical field capacity. Field efficiency is calculated in per cent using the given formula (Bainer *et al.*, 1987)

$$\eta = \frac{AFC}{TFC} \times 100$$

Where,
AFC = Actual field capacity, ha/h
TFC = Theoretical field capacity, ha/h

I. Draft measurement

Measurement of draft was done using dynamometer. Dynamometer was tied between beam and yoke and the machine was operated in the field. Readings were taken randomly for 5 times. These readings of pull obtained in N were put in the formula to find out the horizontal component of pull,

$D = P\cos\theta$
Where,
D = Draft, N
P = Pull, N
θ = Angle of inclination of beam

J. Power requirement

Data obtained by testing for draft and speed of operation were used to calculate the power requirement of the developed machine. The obtained data were put in the given formula

$$\text{Power (kW)} = \frac{\text{Draft (N)} \times \text{speed } (\frac{m}{s})}{1000}$$

K. Cost of operation

Cost of operation of the implement was calculated using overhead cost, variable cost and actual field capacity. Per hour overhead cost and variable cost were calculated. Sum of these gave the cost of operation per hour. The ratio of cost of operation per hour and actual field capacity gave the cost of operation per hectare. Cost of operation per hectare was calculated separately for soybean, green gram and fodder maize.

L. Overhead cost

Overhead cost included depreciation and interest on investment. For calculating depreciation, straight line method was used.

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

Where, D = Depreciation per hour.

C = Capital investment, □
S = Salvage value, 10% of capital.
L = No. of working hour per year
H = Life of implement in years

Interest on investment at 12 per cent per annum

$$I = \frac{C+S}{2} \times \frac{i}{H}$$

Where, I = interest per hour

i = Rate of interest per annum

M. Variable cost

Variable cost included repair and maintenance cost and hiring charges of bullock pair with operator.

$$R = \frac{C \times m}{L}$$

Where,
R = Repair and maintenance charge per hour
m = Repair and maintenance rate, 6 % of capital cost
C = Capital investment, □
H = No. of working hour per year

Local charges were considered as hiring charges of bullock pair with operator.

Fig. 1 : View of developed three row animal drawn multi crop planter cum herbicide applicator

Fig. 2: View of planter cum herbicide applicator during field operation

III. RESULTS AND DISCUSSION

A. Laboratory Test Result

The average seed rates for soybean, green gram and fodder maize were found out to be 77.85 kg/ha, 17.66 kg/ha and 42.86 kg/ha respectively which were close to the recommended seed rates. Metering rotor number 8 with exposure scale number 1, metering rotor number 4 with exposure scale number 5 and metering rotor number 5 with exposure scale number 2 were found suitable obtained the seed rates closer to the recommended values for soybean, green gram and fodder maize respectively (Table 1).

Table 1: Optimum seed rates for different crops

Crop	Recommended seed rate (kg/ha)	Rotor number	Exposure scale	Average seed rate obtained (kg/ha)

Soybean	65-75	8	1	77.85
Green gram	15-20	4	5	17.66
Fodder maize	40	5	2	72.86

B. Mechanical damage to seeds by metering mechanism

Mechanical damage to the seeds by metering mechanism was recorded through visual observation. The damage percentages of soybean, green gram and fodder maize were found out to be 0.56 per cent, 0.86 per cent and 64 per cent respectively (Table 2). The damage percentage was less than 1% significance for all three selected crops.

Table 2: Mechanical damage to seeds by metering mechanism

S. No.	Crop	Weight of broken seeds, g	Total weight of sample, g	Seed damage %
1	Soybean	5.6	1000	0.56
2	Green gram	8.6	1000	0.86
3	Fodder maize	6.4	1000	0.64

C. Spray distribution pattern

Spray distribution pattern depended on the spray angle, pressure, number of nozzles, spacing between adjacent nozzles and nozzle height. Different spray pattern were obtained by changing the spacing between nozzles and nozzle height. Band width of spray increase with the increase in pressure developed in boom. Discharge rate from three flat fan nozzles was measured in ml/min at the pressure 254.97 kPa. The discharge rates were found out to be 321.8 ml/min, 313.8 ml/min and 329.6 ml/min for nozzles N_1, N_2 and N_3 respectively (Table 3). The total discharge rate of boom was 965.2 ml/min.

Table 3: Factors affecting spray distribution pattern

S. No.	Particular	Observation
1	Number of nozzles	3
2	Spacing between adjacent nozzles, mm	230-450
3	Height of nozzle, mm	350-550
4	Pressure developed in boom, kg/cm^2	2.1-2.9
5	Spray angle, °	60

D. Machine Performance

The developed sprayer cum planter was tested in the research area field of 21x19 m² at SVCAET&RS, IGKV Raipur (C.G.). Missing and multiple indices were calculated for the seed spacing of 50 mm, 100 mm and 150 mm for soya bean, green gram and fodder maize respectively. Missing index was found 13.2, 8 and 10.2 per cent for Soybean, green gram and fodder maize respectively. Multiple index was observed as 12, 9.4 and 11.8 per cent for Soybean, green gram and fodder maize respectively. The pressure was recorded from the pressure gauge at five different instances. The pressure values recorded ranged from 2.1 to 2.9 kg/cm^2. The average pressure developed in the boom was found out to be 2.6 kg/cm^2.

The average draft of the implement was found out to be 443 N. The actual field capacity for soybean, green gram and fodder maize was found out to be 0.183 ha/h, 0.124 ha/h and 0.121 ha/ h respectively. Time required to cover 1 ha area was found to be 5.46 h/ha, 8.06 h/ha and 8.26 h/ha for soybean, green gram and fodder maize respectively. Herbicide application was also carried out in this time. Field efficiency for soybean, green gram and fodder maize was calculated and found out to be 78.2%, 72.5 % and 70.7% respectively.

The estimated cost of implement including material cost and fabrication cost was calculated out to be 15000. The cost of sowing operation per hectare was calculated separately for selected crops and the results obtained were 430/ha, 634/ha and 650/ha for soybean, green gram and fodder maize respectively. The average cost of sowing operation was 573/ha. Operational energy was calculated separately for the selected crops and the results obtained were 77.89 MJ/ha, 114.95 MJ/ha and 117.81 MJ/ha for soybean, green gram and fodder maize respectively. The average operational energy was found out to be 103.55 MJ/ha.

Table 4: Machine performance result of multi crop planter cum herbicide applicator

Crops **Parameters**	**Soya bean**	**Green gram**	**Maize**
Missing Index, %	13.2	8	10.2
Multiple Index, %	12	9.4	11.8
Depth of operation, mm	37.45	48.35	44.67
Pressure in boom, kg/cm^2	2.4	2.8	2.6
Speed of operation. Km/h	1.86	1.80	1.82
Draught, N	427	459	444
Power output, kW	0.21	0.23	0.22
Theoretical field capacity, ha/h	0.234	0.171	0.171
Actual field capacity, ha/h	0.183	0.124	0.121
Time required to cover 1 ha, h/ha	5.46	8.06	8.26
Field efficiency, %	78.20	72.50	70.70
Cost of operation, Rs./ha	430	634	650
Operational energy, MJ/ha	77.89	114.95	117.81

IV. CONCLUSIONS

Performance of the three row animal drawn multi crop planter cum herbicide applicator was evaluated through laboratory tests and field tests and the results obtained were satisfactory. The developed machine was found to be worked satisfactorily. The average draft requirement was within the pulling capacity of medium size bullocks of this region. The average seed rates obtained were close to the recommended seed rates. The values obtained for damaged seed percentage, missing index and multiple index were insignificant. The multi crop planter cum herbicide applicator was cost effective energy efficient. Based on the results obtained, it is clear that the implement is useful to farmers falls under small and marginal land holdings.

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