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Performance Evaluation of Bullock Drawn Three-Row Inclined Plate Planter

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A B S T R A C T

The bullocks and buffaloes are the main stay of farm power in India and they still command over 60% of the total cultivable land. About 90% of the tillage operation in India is still carried out by the draught animals. The study was conducted on CIAE made animal drawn three row inclined plate planter at OUAT field. In this study the performance and cost-economics were compared for maize seed. During the study it was found that the mean draft requirement measured during experiment was 384.17 N with an average power output of 0.158 kW/ h. The average speed of operation of the planter was found to be 1.46 km/h. The average seed to seed distance was 30 cm and average row to row distance is 45 cm. The depth of seed placement was 6 cm and actual seed rate observed was 13.2 kg/ha. The theoretical field capacity was 0.127 ha/hr. The field efficiency calculated was 70.5 %. The mean draft measured during experiment was observed to be 351.83N. The average speed of operation behind the plough was 1.54 km/h. The average seed to seed distance was 27.5 cm and average row to row distance is 41cm. The average depth of seed placement was 8 cm and actual seed rate observed was 22.5 kg/ ha. The theoretical field capacity was found to be 0.075 ha/hr. The field efficiency was calculated to be 59 %. It was found that cost of sowing with three row inclined plate planter was Rs30.00/ h and sowing behind the plough was Rs. 50.00/ h.

Introduction

Agricultural development is usually regarded as a major requirement for overall development of any country. Crop cultivation in India requires application of both animate (bullock, human power) and inanimate (tractors, tillers etc.) forms of energy at different stages. After tillage operation, sowing is done. Sowing is an art of placing seeds in the soil to have good germination in the field. Different types of sowing methods generally adopted are (i) Broadcasting (ii) Dibbling (iii) Seed dropping behind the plough and Hill dropping (iv) Seed Drill and Planter. Broadcasting is the method of random scattering of seeds on the surface of seedbed. It can be done manually or mechanically. Soon after broadcasting, the seeds are covered by planking or some other devices. Usually higher seed rate is obtained in this system. Dibbling is the process of placing seeds in holes made in the seedbed and closing the seed with soil. In this method,

seeds are placed in holes made at definite depth at fixed spacing. The equipment used for dibbling is called *dibbler*. Mostly vegetables are sown in this way. Seed dropping behind the plough is a very common method of sowing followed by the farmers in villages. This method is used for seeds like maize, gram, peas, wheat and barley. A woman/ man walk behind the plough and drop the seeds in the furrows made by plough. This method is a slow and laborious one. In hill dropping method, few seeds are dropped as a hill at a fixed place and not in a continuous stream. The spacing between hill to hill in a row is constant. A perfect sowing gives, correct amount of seed per unit area, correct depth of sowing, correct spacing between row-to-row and plant to plant and correct seed rate which can be achieved by use of seed drills or planters. Use of these implements not only reduces human drudgery and laborer cost but also ensures the timeliness of operation. Of course proper field preparation with finely pulverized soil is a pre requisite for better performance of the seed drill and planter. In seed drill seeds are dropped the in furrow lines of the drill in a continuous stream and covering them with soil. But the spacing between the seeds is not uniform. The number of rows may be one or more. Planter is sowing equipment used for sowing those seeds which are larger in size and cannot be handled by seed drills. Row to row and plant to plant spacing is maintained in a planter. Function of a planter is to open the furrow, meter the seed, deposit the seed in the furrow, covering the seed with soil.

To achieve the best performance from a seed drill or planter, the above factors are to be optimized by proper design and selection of the components required on the machine to suit the needs of the crops. The seed drill or planter can play an important role in manipulating the physical environment. The metering system selected for the seed should not damage the seed while in operation. The speed of metering device is a very important factor with regards to damage. Seed damage can be avoided by selecting the proper spring loading rate of the cut-off device and knock-out device in case of plate type planters.

The bullocks and buffaloes are the main stay of farm power in India and they still command over 60% of the total cultivable land. About 90% of the tillage operation in India is still carried out by the draught animals. The marginal farmers who constitute 80% of the total farming community of the country with low purchasing capacity extensively depend on draught animal power for different agricultural operations.

At the same time shortage of agricultural laborers due to rapid urbanization is a constraint in crop production. In this context there is a huge scope for introduction of various matching bullock drawn implements like seed drills and planters. According to Adekanye *et al.*, (2015) the field capacity of a multi-crop planter is 76.3% and seed rate varies from 0.18 to 0.25 kg/ha for different crops. The present study on "performance evaluation of an animal-drawn three row inclined plate planter" was undertaken with the following objectives:

To study the performance of CIAE animal drawn three row inclined plate planter for sowing of maize.

To compare the cost-economics of the inclined plate planter and seed dropping behind the plough.

Materials and Methods

A CIAE developed animal drawn 3 row inclined plate planter was tested for sowing of maize with a pair of medium size bullock having a pair weight of 520 kg. Field trials were conducted in the Central Farm of OUAT, Bhubaneswar situated at latitude

20.27^0 N and longitude 85.84^0E at an elevation of 45m above the sea level.

Features of inclined plate planter

The inclined plate planter is a multi-crop planter developed for planting of bold and small seeds. It has three independent seed boxes with inclined plate edge drop type seed metering mechanism. The planter has shoe type furrow openers which ensure deeper seed placement in moist zone for sowing under dry land conditions. An optional fertilizer box with fluted roller type metering system can also be mounted on the main frame for application of granular fertilizers.

Power from ground wheel is transmitted to the counter drive shaft through a set of chain and sprockets. Another set of sprockets on the counter shaft transmits the power to main drive shaft. Main drive shaft drives the individual drive shafts of modular seed boxes through sets of chain and sprockets and these shafts in turn rotate the inclined seed metering plates through a set of bevel gears.

Drive ratio between ground drive wheel and seed plate can be changed, by selecting appropriate size of sprocket on wheel axle or on counter and main drive shafts.

Calibration of planter

The animal drawn 3 row inclined planter was calibrated to get the desired seed rate for the crop taken i.e., maize. Wide range of quantity of seeds dropped through the inclined plate was collected during the calibration of planter. For calibration of planter:

Nominal width of planter was determined i.e. number of furrows x spacing between the openers. Nominal width= 30x3 = 90cm = 0.9m

Diameter of ground wheel was found out i.e. total diameter + 1 peg height = 42cm = 0.42m.

The planter was jacked up. A mark on the ground wheel to count revolutions was made. Ten revolutions were taken. Distance covered in 1 revolution= πD = $1.32m^2$. For 10 revolutions, area covered= 1.32x10 =$13.2m^2$

Seed was put in seed box.

Seeds dropped from each furrow were collected, counted and weighed.

Seeds dropped in kg/ha were calculated and recorded.

The process was repeated for different speeds (1.5 to 3 km/h) and for different hopper capacity to get the desired seed rate.

No. of seeds dropped per box in 10 revolutions = 60

Required row to row distance= 45cm, Seed to seed distance= 30cm, No. of seeds per ha= 45,454

As 1000 seeds weigh 250gram, 45454 seeds weigh= 11.3kg

As from calibration of the inclined plate planter, the seed rate was found nearly equal to the desired seed rate for maize i.e. 12 kg/ha; at full hopper capacity and speed of 1.5km/h, the inclined plate planter can be used for sowing of maize appropriate spacing.

Determination of soil moisture

The soil sample was collected on the day of operation and kept in clean moisture cups, weighed and put with lid opened in a thermostatically controlled oven with interior of non-corroding material to maintain the

temperature between 105^0C to 110^0C. Weight of the samples were taken every 24 hours intervals till the weight became constant, so that complete drying is assured. After drying, the container is removed from the oven and allowed to cool in desiccators before weighing.

The water content was calculated from the following expression:

$W= (M_2-M_3) / (M_3-M_1)*100$

Where,
M_1 =mass of the container with lid

M_2 = mass of container with lid and wet soil

M_3 = mass of container with lid and dry soil

Measurement of physiological parameters of bullocks and ambient conditions

The hourly ambient temperature and relative humidity were recorded by a room temperature recorder and a hygrometer, respectively during the experimental period. The instruments were kept hanging from a stand during the work at the experimental site.

Heart rate of the bullocks was measured by using a stethoscope, putting it on left side of the chest in between 4th to 6th rib for one minute. *Respiration rate* was measured by feeling the blows of expired air on the backside of the palm over nostril for one minute. Body temperature was recorded from rectal wall by help of a clinical thermometer. The degrees of distress symptoms like frothing, leg in-coordination, excitement, inhibition to progressive movement and tongue protrusion were recorded by visual observations.

Fatigue score of the bullocks was determined as per the fatigue scorecard (Table 2) developed by Upadhyay and Madan (1985). In this scorecard, one point is scored for every rise of ten counts in heart rate, fifteen counts in respiration rate and 0.5^0 C in body temperature. Similarly, points are scored for different degrees of distress symptoms like frothing, leg in-coordination, excitement, inhibition to progressive movement and tongue protrusion as manifested by the bullocks during work.

The maximum point can be scored, for any response or symptom is 5 and the total score of all eight fatigue parameters in this scorecard is 40. But the bullocks are said to be fatigue when total score reaches 20 i.e. 50% of the highest score.

Field experiments

The theoretical field obtain if implement was performing its function 100% of the time at the rated speed and always covering 100% of its rated width. Field capacity was calculated by following expression:

$TFC = (W \times S) / 10$

Where,
TFC = theoretical field capacity,

W = theoretical width of implement, m and S = speed of operation.

Actual field capacity was determined by expression given as:

$AFC = A / T$

Where,
AFC = Actual field capacity, A = actual area covered by implement, ha and T = effective time, h.

Field Efficiency is determined by the ratio of actual field capacity and theoretical field capacity.

Draft was measured by using a dynamometer (Fig. 1). Power output in kw/h was determined by expression given as:

P = Draft in kg x Speed in km x 0.0028 kW/h

Average seed to seed and row to row distance was measured.

Depth of placement of seed was measured using a steel ruler.

Area was measured using pegs and measuring tape. And time was noted using stop watch. These measurements were taken for calculating actual field capacity.

Results and Discussion

The field evaluation of the animal drawn 3-row inclined plate planter was done at the Central farm of OUAT, Bhubaneswar, Odisha during summer season. The crop taken was maize of variety PDM 54. The soil of experimental site comes under sandy loam texture. The field was ploughed thrice for well pulverization of the soil which is a prerequisite for smooth operation of seed drill/ planter. The soil moisture content was 21.02 % and the mean diameter of the clods was 0.38 mm. The entire field was divided in to two equal portions for sowing of maize by inclined plate planter and behind the plough (Traditional practice) for comparison of different machine and crop parameters. The performance of the inclined plate planter and sowing behind the plough has been presented in Table 3.

Inclined plate planter

The draft requirement for the operation was varied from 372.4N initially to 401.8 N at 2nd hour of operation with an average power output of 0.158 kW. The average speed of operation of the planter was found to be 1.46 km/h. The average seed to seed distance was 30 cm and average row to row distance is 45 cm. The depth of seed placement was 6 cm and actual seed rate observed was 11.2 kg/ha. The mean draft requirement measured during experiment was 384.17 N. The theoretical field capacity was 0.127 ha/hr. The field efficiency calculated was 70.5 %. Average number of plants per hill was one. Cost of labour charges was Rs 500.00 per ha in sowing with three row inclined plate planter.

The physiological responses of the bullocks during the operation of the inclined plate planter have been presented in Table 4. Ambient temperature ranged from 30^{0}C to 32^{0}C and relative humidity ranged from 56% to 70%. The heart rate, respiration rate and body temperature increased up to 72 beats/min, 36 blows/min and 38.7^{0}C after two hour of operation. The fatigue score of the bullocks was observed to be 15, well within safe limit of 20. Thus, a medium pair bullock could be able to operate the inclined plate planter comfortably.

Behind the plough

The average speed of operation behind the plough was 1.54 km/h. The average seed to seed distance was 27.5 cm and average row to row distance is 41cm. The average depth of seed placement was 8 cm and actual seed rate observed was 22.5 kg/ha. The mean draft measured during experiment was observed to be 351.83N. The theoretical field capacity was found to be 0.075 ha/hr. The field efficiency calculated to be 59 %. Average number of plants per hill was 1.34. Cost of labour charges was Rs 2140.00 per ha in sowing behind the plough. The physiological responses of the bullocks during the sowing behind the plough have been presented in Table 5. Ambient temperature ranged from 31^{0}C to 32.4^{0}C and relative humidity ranged from 58% to 69%.

Table.1 Specifications of the CIAE inclined plate planter

S. No.	Particulars	Specifications
1	Overall dimensions (mm)	1200x1300x900
2	Number of rows	3 (row spacing adjustable from 25 to 45 cm)
3	Seed metering	Inclined plate with cells, 120mm diameter
4	Fertilizer metering	Aluminum fluted rollers
5	Furrow openers	Shoe type
6	Power source	Medium size pair of bullock
7	Power transmission	Through chain & sprocket and bevel gear
8	Ground wheel	Present
9	Depth Adjustment wheel	Present (2 nos.)
0	Clutch mechanism	Available
1	Seed & fertilizer channel	Plastic tube (1")
2	Seed & fertilizer dropping	Free flow by gravity

Table.2 Fatigue scorecard for bullocks

Physiological responses	Scores					Maximum score
	1	2	3	4	5	
Heart rate (beats/min)	H + 10	H + 20	H + 30	H + 40	H + 50	5
Resp. rate (blows/min)	R + 15	R + 30	R + 45	R + 60	R + 75	5
Body temp (^{0}C)	T + 0.5	T + 1.0	T + 1.5	T + 2.0	T + 2.5	5
Frothing	First appearance	Dribbling of saliva	Continuous dribbling	Appearance of froth	Full mouth frothing	5
Leg in-coordination	Strides uneven	Occasional dragging	Frequent dragging	No co-ordination	Unable to move	5
Excitement	Composed	Disturbed	Nostrils dilated	Eye balls dilated	Furious ness	5
Progressive movement	Brisk	Free	Slow	Very slow	Stop walking	5
Tongue protrusion	Mouth closed	Occasional opening	Frequent appearance	Continuous protrusion	Tongue fully out	5

Table.3 Performance evaluation of inclined plate planter and sowing behind the plough

Sl. No.	Particulars	Inclined plate planter	Behind the plough
1	Crop	Maize	Maize
4	Type of soil	Sandy loam	Sandy loam
5	Soil moisture, % (db)	21.02	21.02
6	Mean weight diameter of clods, mm	0.38	0.38
7	Average speed, km/hr	1.46	1.54
8	Avg. seed to seed distance, cm	30cm	27.5cm
9	Average row to row distance, cm	45cm	41cm
10	Depth of seed placement, cm	6	8
11	Actual seed rate observed, kg/ha	11.2	22.5
13	Draft, kg	39.3 kg (7.5% of the body weight)	35.9 kg(6.9 % of the body weight)
14	Theoretical field capacity, ha/hr	0.127	0.075
15	Field efficiency, (%)	70.5	59
16	Average number of plants /hill	1	1.34
17	Labour cost (Rs/ ha)	500.00	2140.00

Table.4 Physiological parameters of Bullocks during sowing with inclined plate planter

Parameters	Duration of work					
	Initial	**0.5**	**1.0**	**1.5**	**2**	**Mean**
Amb. Temp., ^{0}C	30	30.4	30.9	31.4	32	30.94
Rh, %	56	59	62	66	70	62.6
Draft, N	-	372.4	377.3	385.2	401.8	384.17
Speed, km/h	-	1.50	1.46	1.44	1.42	1.46
Pulse rate, bpm	48	56	60	66	72	-
Respiration rate, bpm	14	18	26	30	36	-
Body Temp, ^{0}C	37.5	37.9	38.2	38.4	38.7	-
Fatigue score	-	9	11	13	15	-
Power output, kW/h	-	0.154	0.156	0.159	0.166	0.158

Table.5 Physiological parameters of bullocks during sowing behind the plough

Parameters	Duration of work					
	Initial	**0.5**	**1.0**	**1.5**	**2**	**mean**
Amb. Temp., ^{0}C	31	31.4	31.8	32.2	32.4	31.77
Rh, %	58	61	64	67	69	63.8
Draft, N	-	343	347.8	354.7	360.6	351.53
Speed, km/h	-	1.60	1.56	1.50	1.48	1.54
Pulse rate, bpm	48	54	58	62	66	-
Respiration rate, bpm	14	18	24	28	32	-
Body Temp, ^{0}C	37.5	37.8	38.1	38.3	38.6	-
Fatigue score	-	9	10	12	14	-
Power output, kW/h	-	0.151	0.153	0.156	0.158	0.155

Table.6 Comparison of cost economics of sowing with animal drawn inclined plate planter and behind the plough

Machine	Fixed cost, Rs/h	Variable cost, Rs/h	Total cost, Rs/h
Three row planter	1.17	0.67	1.84
Bullock pair	3.91	5.00	8.91
One pair bullock + one labourer	3.91	16.00	19.91
Sowing with three row planter	-	-	**30.66**
Sowing behind the plough	-	-	**50.00**

Inclined plate planter and it seed metering mechanism

Fig.1 Draft measurement of planter by dynamometer

Fig.2 Sowing behind the plough

The heart rate, respiration rate and body temperature increased up to 66 beats/min, 32 blows/min and 38.6^{0}C after two hour of operation. The fatigue score of the bullocks was observed to be 14, well within safe limit of 20.

Thus, a medium pair bullock could be able to operate the inclined plate planter comfortably. The cost economics of sowing of maize with animal drawn planter and behind the plough was compared. It was found that cost of sowing with three row inclined plate planter was Rs30.00/ h and sowing behind the plough was Rs50.00/ h (Fig. 2).

A CIAE developed animal drawn 3 row inclined plate planter was tested for sowing of maize with a pair of medium size bullock having a pair weight of 520 kg. The planter has adjustable seed boxes along with shoe type furrow openers. Power from ground wheel is transmitted through sets of chain and sprockets and in turn rotates the inclined seed metering plates through a set of bevel gears. The entire field was divided in to two equal portions for sowing of maize by inclined plate planter and behind the plough (Traditional practice) for comparison of different machine and crop parameters.

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The depth of seed placement was 6 cm and actual seed rate observed was 13.2 kg/ha. The theoretical field capacity was 0.127 ha/hr. The

field efficiency calculated was 70.5 %. Average number of plants per hill was one. Cost of labour charges was Rs 500.00 per ha in sowing with three row inclined plate planter. The fatigue score of the bullocks was observed to be 15 after two hours of work, well within safe limit of 20.

The mean draft measured during experiment was observed to be 351.83N. The average speed of operation behind the plough was 1.54 km/h. The average seed to seed distance was 27.5 cm and average row to row distance is 41cm.

The average depth of seed placement was 8 cm and actual seed rate observed was 22.5 kg/ ha. The theoretical field capacity was found to be 0.075 ha/hr. The field efficiency was calculated to be 59 %.

Average number of plants per hill was 1.34. Cost of labour charges was Rs 2140.00 per ha in sowing behind the plough. The fatigue score of the bullocks was observed to be 14, well within safe limit of 20.

The cost economics of sowing of maize with animal drawn planter and behind the plough was compared. It was found that cost of sowing with three row inclined plate planter was Rs30.00/ h and sowing behind the plough was Rs50.00/h (Table 6).

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