International Journal of Agricultural Engineering, Vol. 4 No. 2 (October, 2011) : 193 -199

Research Paper :

Performance evaluation of bullock drawn multi crop inclined plate planter

SANJAY KUMAR NIRALA

Received : July, 2011; Accepted : September, 2011

Correspondence to:

SANJAY KUMAR NIRALA
College of Agricultural Engineering, R.A.U., Pusa, SAMASTIPUR (BIHAR) INDIA
Email : sanjavaiit@yahoo.co.in

ABSTRACT

Three - row bullock drawn multi-crop inclined plate planter was developed at C.I.A.E Bhopal for sowing different type of crops. The calibration for the seed and fertilizer rate was done in the laboratory of C.A.E. R.A.U. Pusa Samastipur. The seed rate was found 20.60 kg/ha for the maize crop and fertilizer rate was found from 9.3 kg/ha to 124.3 kg/ha. The wheel skid was in tolerable limit as it was recorded 4.53 %. The field capacity was 0.23 ha/hr and field efficiency was 51.1 %. The plant population was found 10 – 12 plants per square meter. The cost of sowing per hacter was 3.5 times economical than traditional method.

Sanjay Kumar Nirala (2011). Performance evaluation of bullock drawn multi crop inclined plate planter. *Internat. J. Agric. Engg.*, **4**(2) : 193-199.

Key words : Bullock drawn, Inclined plate planter, Field capacity, Field efficiency

Improvement of socio-economic condition and growth of the country depend on the development of agriculture. The effective demand of food grain is expected to be around 265.8 million tons by 2020 AD against the production level of 223 million tons. So our country is in great need of increase in food grain production.

Maize is one of the important cereal crops. The average production of maize in India is 8.66 million tons, but at present demand is 10.28 million tons. Expected demand in 2015 and 2030 would be 11.71 and 12.87 million tons, respectively (Source - Economic Survey).

Sowing is one of the important agricultural operations for raising crops. Proper application of fertilizer at proper location has also a good effect on crop growth and yield and seed rate, proper placement of seed fertilizer and row spacing are also necessary. The main reason for increase in yield is the uniform and controlled application of fertilizer with respect to seed in a concentrated bond at about 50 mm below and 50 mm away from the seed.

Traditional method of sowing is not suitable for growing the crop. The result is very low production. There are many faults such as not proper seed rate, fertilizer rate so several type of planter has been developed by various research organization and agricultural engineering institutions. Bullock drawn inclined plate planter has been developed by C.LA.E. Bophal. The use of bullock drawn inclined plate planter to increase the grain yield is very necessary because of the farmers of India are very poor. They are not able to purchase the tractor and power tiller.

The most important source of power in the farm all over the third world and especially in India is animal. Animals are the largest contributor of farm power in India and yet, the major source of marginal, small and even medium farmers who account for more than 80% of total agricultural holding and 40% of total cultivated

The machine combines there function is seed drill or planter. The basic difference between seed drill and planter is that a seed drill sows seeds at specified rate and at the proper depth and in rows. It cannot deposit the seeds in hills nor in check rows, where as a planter can deposit seeds at a specified rate in hills and rows spaced to permit inter row cultivation and also function as a seed drill if required, several studies have shown that the use of planter increase the yield by 15 to 25% and may increase up to 40% depending upon the crop variety. Increase in yield is due to uniform and controlled drilling of fertilizer with respect to seed in a concentrated band. Fertilizer is placed about 5 cm below and 5 cm away from the seed which provides good environment for root development. As soon as germination takes place, root branches go down at about 45^0 angle in soil and come into direct contact of fertilizer within a few days after germination.

History and Background:

Seeding by hand was practiced universally untill the middle of last century. The history of grain drill is a part of the history of man's fight for survival through the ages, as it records his various effects to improve his first method of a sowing, which was broadcasting the seed by hand on the top of the furrowed soil. From the beginning of recorded history up to year 1731, very little work had been accomplished towards making a machine for sowing grain. In 1799, the first grain drill was built in United States of America, but it could not do the accurate and uniform sowing. Davidson and Chase (1908) studied that a sort of drill plough was developed in Assyria long before the christian era. Broadcasting seed over broken soil and covering them with some type of harrow was common method of planting untill about 1840.

According to Bernacki (1972), the first European drill was developed in 1636 by Joseph locatelli of Corinth. The machine was named as "Sembradore". It has a cylindrical wooden tank inside which a shaft with spoon rotated throwing seeds through holes into sagging tube falling on the soil surface. The machine could not deposit seeds in the ground but laid them only in rows on the surface none the less, in comparison with manual sowing seed location was less confused.

Seed metering/placement:

Roy (1947) suggested that the planter employing inclined plates were capable of uniform metering of seeds. It was essential that the cells in the plates fit seed to be planted. The diameter of the cell should be 1/64 inch larger then the maximum diameter of the seed to ensure proper clearance. Movement of seed through cell could be further improved by tapering the cell wall from top to bottom. The tapering to an inclined angle of approximately 12^0C was sufficient to ensure free movement of seed through the cell.

Under ICAR Co-ordinated scheme on farm implement and machinery at pune centre, a three rows animal drawn multi crop planter was developed for Tamil Nadu, popularly known as planter. It is used for planting various crop like groundnut, sorghum. Bengal gram, green gram etc. Different rotors were provided for different crops and seed rate was also controlled by the size of the rotors. This unit was extensively tested and its performance were found to be satisfactory (Devnani, 1982 a).

Under the similar scheme at Ludhiana centre, a tractor drawn seed-cum fertilizer drill-cum- planter was developed for Punjab. For drilling seeds, fluted rollers metering device was used. For planting unit, inclined plates with not shed cells were used. The cell plates were selected according to crop (Devani, 1982 b). The plant to plant spacing was regulated by changing the speed of drive system. The unit was extensively used for sowing groundnut, sorghum. Bengal gram etc. with its satisfactory work performance.

Kumar (1984) designed and fabricated a manually operated single row planter using different seed plates having differences in size of cells. The seed plates were devided into two halves so that they could easily be replaced. This planter was tested for maize, pea, and arhar seeds. It was suggested that the size of drive wheel should be increased to facilitate better seed placement with more spacing between the two seeds by obtaining more ground clearance.

MandaI and Ojha (1986) developed a manually operated four rows seed drill. Separate wooden discs were used for metering different size or number of drilling for different seeds. Each disc was splited into two halves to make it easy to replace by lock nut into the collar which was fixed on the shaft. The seed cut off device was of thick belt and a frame rubber pad on it. This seed drill was tested and performance was founded to be satisfactory.

Fertilizer metering / placement:

Sethi and Prakash (1973) designed and developed a fertilizer metering device and then tested. They concluded that the parabolic hopper with diamond opening and anger type agitator did not allow any bridge formation due to the two way action and helps for free flow fertilizer towards the opening, head of fertilizer had no significant effect on average delivery of fertilizer. In case of anger type agitator, it has no effect at all.

Jadhav and Bote (1990) developed a low cost and high utility device at Agricultural Engineering Research Centre, Pune to transport wet land paddy with a recommended plant geometry of 0.15 x 0.20 m and to facilitate applying urea supper granules (USG) during transplanting at recommended rates without damaging the granules. This device is called the row plant spacmg (RPS) marker-cum-USG dispenser.

Furrow openers:

Verma (1982) conducted trials on different type of seeding machineries in farmers field under All India Co-ordinated Research Project for Dryland Agriculture in Hashiyarpur district. None of the furrow openers used with these seed drills were found suitable for deep sowing. Farmers liked deep furrow seeder with simple design for its easy handling.

Shukla *et al.* (1987) developed a roatary blade till attachment for direct sowing operation. The machine could be operated by a tractor of 35 HP and above. The machine was evaluated for sowing wheat after maize and paddy and maize after wheat. Randomized Block Design was used for the evaluation in comparison to the conventional tillage and sowing practices. Both mechanical and chemical weeding treatment were studied. Germination count and the yield was comparable to the conventional tillage and sowing practices. Saving in time, fuel and production cost over the conventional tillage and sowing practices were 4.33 to 11.33 h/ha, 50.79 to 70.03 per cent and 2.68 to 14 per cent, respectively

Khan *et al.* (1990) suggested that inverted "T" furrow openers are best suited for better seed germination while establishing technical consideration for the selection of seed-cum- fertilizer drill. This type of drill could be used in both cultivated and no till field conditions and for direct seeding of wheat in rice stubble fields.

Considering above points a bullock drawn inclined plate planter (C.I.A.E. model) was tested with following objectives: to calibrate multi crop planter for seed (maize) and fertilizer metering, to evaluate planter under field condition and to compare the economics of sowing with traditional method.

METHODOLOGY

This chapter deals with the methodological approach followed in the laboratory as well as in actual field for testing of bullock drawn 3-row inclined plate planter.

Description of 3 row multicrop bullock drawn inclined plate planter:

– Make : C.I.A.E. Bhopal
– Power source : Pair of bullock
– Overall dimension:
  - Length : 182 cm
  - Width : 127 cm
  - Height : 94 cm
– Seed box
  - Shape : Trapezoidal
  - Length : 17.7 cm
  - Bottom width : 7.5 cm
  - Depth : 20.50
– Fertilizer tank
  - Shape : Trapezoidal
  - Length : 78 cm
  - Width : Top width = 24 cm; Bottom width = 20 cm
  - Depth : 21.50 cm
– Rated working width of the machine : 180 cm
– Number of rows : 3
– Row to row spacing : 60 cm
– Type of furrow openers : Shoe type
– Dia. of ground wheel
  Top dia. = 62 cm
  Base dia. = 45 cm
– Height of peg star wheel: 8 cm
– Number of pegs : 12
– Location of star : Side of the planter
– Type of power transmission: Chin and gear drum
– Type of seed metering mechanism : Inclined plate rotor type
– Type of fertilizer metering mechanism : Fluted roller with adjustable opening
– Speed ratio
  Ground wheel to seed metering mechanism: 2.64: 1
  Ground wheel to fertilizer metering mechanism: 2.64: 1
– Crop suitability : Multicrop planting, maize, sunflower, wheat, gram, pea etc.

Location of the experimental site:

The bullock drawn 3 row inclined plate planter was tested in the actual field near the Farm machinery shed of C.A.E.,R.A.U., Pusa. The farm is located at an altitude of 52.92 m above the sea level, $25^0 29'$N latitude and 83°49' longitude. The climate of the area is humid with average rainfall of 1270 mm and temperature goes up to 45^0C in June-July and minimum about 6^0C in December. The soil was calcareous sandy loam. Bulk density ranged from 1300-1400 kg/m^3

Experimental procedure:

Laboratory testing of machine:

All the moving components of the machine were lubricated properly. It was attached with bullock to observe the movement pattern. It was then calibrated for proper seed rate and fertilizer rate.

Calibration of inclined plate planter:

The procedure of testing the planter for correct seed and fertilizer rate is called calibration of planter. It is necessary to calibrate the machine before putting it in actual use to find out the confirmation of desired seed rate and fertilizer rate.

The following procedure was adopted for calibration of bullock drawn inclined plate planter.

Number of furrow openers in planter = N
Distance between two furrow openers=W
Diameter of drive wheel = D
Working width of the planter = N x W
Distance covered in 10 revolution of drive wheel = π D x 10 m

Area covered in 10 revolution $= N \times W \times \pi D \times 10\ m^2$
Fertilizer drop in 10 revolution $= Y$ Kg
Then, rate setting will be $= Y/(N x W x \pi D x 10)$ kg/m^2
Or $= Y \times 10^4 / (N \times W \times \pi D \times 10)$ Kg/ Ha.... (1)

Similarly, the different rate setting of fertilizer drop at different opening position was done in order to obtain the calibration curve for fertilizer metering system. The seed drop was also verified with the appropriate cell for sowing maize and other crops by the similar methods.

Measurement of grain crackage:

After calibration of metering mechanism for recommended rate setting of seed and fertilizer, five revolution of ground wheel was given and weight of seed dropped was calculated. The dropped seed was sorted out for fresh or healthy seed and damaged seed. The sorted seed was then counted. Total six readings were taken for each setting. The average value of these readings resulted the percentage damage of seed due to metering mechanism. The following relationship was used for calculation of seed damage.

$\%$ Damage $= N_D / N_T \times 100$ .... (2)

where

N_D = Total number of seeds

N_T = Total number damage seeds

Field testing of machine:

Measurement of field capacity and field efficiency:

The field capacity and field efficiency of the planter was measured for maize planting. The rate setting of planter was done 20.60 kg/ha for maize seed and 124 kg/ha for fertilizer. For planting maize, a plot of size 25 x 7 m was selected. Speed was 2.5 km/h. Effective operating time was measured with the help of stop watch. The field capacity was calculated as following:

The theoretical field capacity was calculated based on the formula given below :

$$\text{Theoretical field capacity} = \frac{S \times W}{10} \text{ ha/h} \text{ .... (3)}$$

where

S = Linear speed of travel of machine in km/h

W = Width of operation of machine in meter

$$\text{Actual field capacity (ha/h)} = \frac{A}{T \times 10^4} \text{ .... (4)}$$

A = Area of plat M^2

T = actual time taken to caver the area, h (including lasses)

$$\textbf{Field capacity \%} = \frac{\text{Actual field capacity}}{\text{Theoretical field capacity}} \times 100 \text{ ......(5)}$$

Measurement of wheel skid:

The measurement of wheel skid was done for star wheel or drive wheel of planter. At first the distance traveled by planter for 10 revolution of the drive wheel was recorded at no load. Then after, four observations were taken for the same number of revolution when operated with load. The average of these observations was calculated.

The percentage wheel skid of the bullock drawn planter was then calculated with the help of recorded data as follow

$\%$ Skid $= (L_1 - L_2)/ L_1 \times 100$ ....(6)

where,

L_1 = actual distance traveled, m

L_2= theoretical distance traveled, m

Measurement of depth and spacing of seed and fertilizer:

The depth and width of furrow, depth of seed and fertilizer placement, lateral distance between seed and fertilizer were measured with the help of steel scale. Depth of seed and fertilizer was measured by placing one scale horizontally on the ground and other scale was kept in furrow vertically. Seed to seed spacing was measured with the help of scale after germination of seed.

RESULTS AND DISCUSSION

The results have been presented under following heads:

Hitching of inclined plate planter with bullock:

The hitching of planter was tested by a pair of bullocks in a well prepared land without sowing the seeds. The machine was allowed to run at its normal working speed of 2.5 km/hr and its hitch with the beam was found to be satisfactory.

Laboratory performance of machine:

The laboratory performance of machine was evaluated for verification of seed drop through respective rollers and metering fertilizer (DAP). Initially all the moving components of planter were lubricated properly and then it was verified for proper seed rate as well as fertilizer rate. The actual fertilizer drop for each furrow opener at full opening (Table 3). The actual calibration curve is shown in Fig. 1. The seed damage due to metering of device was found to be nil. The calibrated seed rate

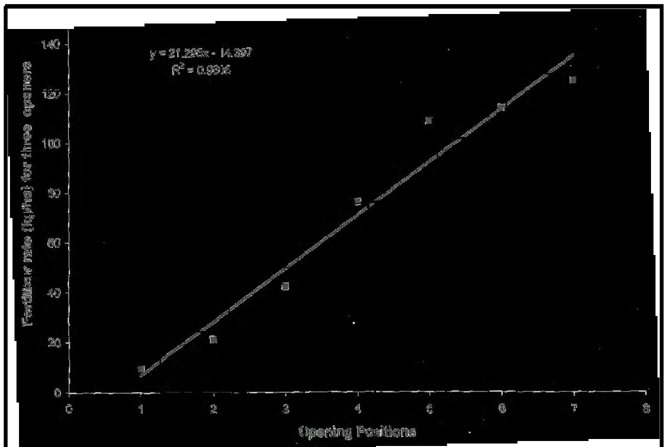

Fig. 4.1 : Calibration curve of inclined plate planter for metering fertilizer

for maize was found to be 20.60 kg/ha which was about recommended seed rate. The high seed rate of maize was obtained due to smaller size of seed, therefore, more than one seed was dropped from the cell at a time.

Distance cover by ground wheel in one revolution $= \pi D = 3.14 \times 0.45 = 1.413$ m

Distance covered by 10 revolutions = 14.13 m

Row to row distance = 60 cm

Area cover by 10 revolution =1.80x14.13=25.34 m^2

25.34 m^2 land seed drop 120.4 gram

Therefore, 10,000 m^2 land seed drop = 47.5 kg/ha

Hence seed rate in first calibration = 47.5 kh/ha

Initially number of teeth in the seed metering sprocket was 19 and the number of teeth in ground wheel sprocket was 14 so the speed ratio was 1.3 : 1. In this case seed rate was more than recommended seed rate. Therefore, by modifying the speed between ground wheel and seed metering device by changing the seed metering sprocket teeth from 19 to 37 teeth. The speed ratio become 2.64:1 and seed rate of the planter was brought down to desired level. Calibration of modified seed rate is presented in Table 2.

Table 1 : First calibration and seed rate

Sr. No.	Numbers of revolution	Seed dropping in furrow (g)			Total seed (g)
		I	II	III	
1.	10	50	49	45	144
2.	10	40	40	40	120
3.	10	50	45	38	133
4.	10	30	30	30	90
5.	10	35	30	30	115
				Average	120.4

Table 2 : Modified seed rate

Sr. No.	Numbers of revolution	Seed dropping in furrow (g)			Total seed (g)
		Furrow I	Furrow II	Furrow III	
1.	10	18	18	17	53
2.	10	17	17	18	52
3.	10	18	17	17	52
4.	10	17	19	18	54
5.	10	17	17	17	51
				Average	52.4

Table 3 : Calibration of planter for metering fertilizer (DAP)

Opening position	Numbers of revolution	Weight of fertilizer dropped in each furrow (kg)				Average rate of metering fertilizer (kg/ha)
		Furrow opener I	Furrow opener II	Furrow opener III	Total	
1.	10	0.012	0.002	0.005	0.019	9.34
2.	10	0.021	0.010	0.012	0.043	21.14
3.	10	0.037	0.022	0.027	0.086	42.28
4.	10	0.060	0.045	0.050	0.155	76.20
5.	10	0.080	0.070	0.070	0.221	108.65
6.	10	0.085	0.072	0.074	0.231	113.56
7.	10	0.087	0.083	0.083	0.253	124.38

Field performance of planter for sowing maize:

After getting satisfactory performance in the laboratory, the machine was taken to the field for actual testing by sowing maize. The seed rate was found 20.60 kg/ha, fertilizer rate 124 kg/ha and row to row spacing 60 m. Wheel skid was measured by operating the planter for five revolution of the ground wheel. Initially, the distance covered by planter for 10 revolution of the ground wheel at no load was measured. The machine was then operated at load, putting the seed metering and fertilizer metering equipment in function and the actual distance traveled was measured. The wheel skid of planter was found to be 4.53 %.

For sowing maize crop, the average depth of furrow was found to be 50 mm width depth placement of seed and fertilizer as 41 mm and 50 mm, respectively, lateral distance between seed and fertilizer placement for maize crop was found to be 45.39 mm.

Draft measurement:

The draft requirement for sowing maize was measured with the help of spring dynamometer. The dynamometer was tied between yoke of bullocks and beam of the planter. The deflection of dial was recorded during operation of the planter. The draft measurement set-up has been shown in Table 4.

Table 4 : Measurement of draft

Depth (cm)	Pull (kg)	Pull,P (average)	Draft=P Cos θ, (kgf) where, θ = 36.80°
4.5	100,105,110,125, 120	112	89.6
7.5	125,120,115,130, 125	123	98.4
10	150,206,160,175, 170	172.2	137.76

The recorded data revealed that the magnitude of draft increased as the depth of operation increases. At depth of 4.5 cm the draft was 89.6 kgf while at 10 cm depth the draft increased to a level of 137.76 kgf (Table 4).

Row to Row distance	60 cm
Plant to plant distance	20 – 25 cm
Plant population	10 to 13 plant /m^2
No. of seed per hill	1 to 2 seed

Field capacity and field efficiency of the planter for sowing maize:

The actual field capacity and field efficiency of the machine was evaluated in the experimental field by observing actual time requirement and area covered. Before testing the machine, the various soil parameters like moisture content, mean mass diameter and bulk density were recorded. The actual and theoretical field capacity for sowing maize crop was found to be 0.230 ha/hr and 0.45 ha/hr, respectively and field efficiencies were calculated as 51.1 %.

Economics of use of machine:

The cost analysis for use of multi crop inclined plate planter with bullock and desi plough were calculated. The cost of sowing with the bullock drawn planter was found to be Rs. 27.50/hr whereas with desi plough by placing seed and fertilizer behind the plough was found to be only Rs. 23.75/hr. The actual field capacity of the bullock drawn planter and desi plough was 0.230 ha/hr and 0.055 ha/hr, respectively. Thus the cost of sowing per hectare with bullock drawn planter and desi plough was Rs. 119.5/ha and Rs. 431.82 /ha, respectively. Therefore, it may be said that sowing with bullock drawn planter is 3.5 times economical than traditional method. In addition to economy, the timely completion of sowing operation as well as enhanced production is an unparellel advantage for the use of planter.

Summary and conclusions:

This 3 row bullock drawn is known multi-crop inclined plate planter and developed under C.LA.E., Bhopal for sowing different type of crops. Thus the project was undertaken with the following objectives:

– To calibrate multi crop planter for seed (maize) and fertilizer metering.
– To evaluate planter under field condition.
– To compare the economics of sowing with traditional method.
– To achieve the above objectives calibration of planter was done in the laboratory for the seed and fertilizer rate. Wheel skid, depth and distribution pattern of fertilizer with respect to seed, field capacity and field efficiency were measured in actual field condition for maize crops. Different soil parameters such as moisture content, bulk density and mean mass diameter were also recorded

Based upon above experimentation the following conclusion was drawn out:

– The inclined plate planter could be easily attached with the bullocks
– The fertilizer rate was found to be from 9.3 kg/ha to 124.3 kg/ha
– The seed rate was found to be 20.60 kg/ha

- Plant population was found from 10 to 12 plants per square meter.
- Row to row distance was 600 mm and plant to plant distance varied from 200 to 250 mm.
- Depth of sowing was 50 mm.
- Spacing between seed and fertilizer was observed to 41.2 mm.
- Field capacity and field efficiency of planter were 0.23 ha/hr and 51.15, respectively.
- The cost of sowing per hacter with bullock drawn planter and desi plough was Rs. 119.5 /ha and 431.82/ ha, respectively. Therefore, it may be said the sowing with bullock drawn 3 row inclined plate planter is 3.5 times economical than traditional.

The seed damage due to metering mechanism was found to be nil.

REFERENCES

Bainer, Roy (1947). Precision planting equipment. Agricultural Engineering. *American Soc. Agric. Engineers,* **28** (2) : 49-54.

Bernacki, H. (1972). *Agricultural machines, theory and construction* (Volume-I). National Technical Information Service, U.S. Department of Commerce, U.S.A.

Davidson, J.B. and Chase, L.W. (1908). *Farm machinery and farm motors*. Orange Judd Company, London.

Devnani, R.S. (1982a). Jyoti planter for Tamilnadu, *Agric. Engg. Today*, **6** (4) : 36-38.

Devnani, R.S. (1982 b). Seed-cum-fertilizer drill-cum-planter (for Punjab). *Agric. Engg. Today,* **6** (4) : 33-35.

Jadhav, R.V. and Bote, N.L. (1990). Design development and field evaluation of RPS marker-cum-USG Dispenser. Agricultural Mechanisation in Asia, *Africa & Latin America,* **21** (2) : 17-20.

Khan, A.S.,Tabassum, M.A and Khan, J. (1990). Selection of seed-cum-fertilizer drill :Technical consideration, *Agricultural Mechanisation in Asia, Africa & Latin America*. **21** (1) : 35-39.

Kumar, A. (1984). Design and fabrication of manually operated single row planter, M.Sc. (Agril. Engg.) Thesis, Allahabad Agricultural Institute, ALLAHABAD, U.P. (India).

Mandal, T.C. and Ojha, T.P. (1986). Manually operated four row seed drill for small seeds. *Agric. Engg. Today,* **10** (4) : 4-6.

Sethi, C.P. and Prakash, C. (1973). Design, Development and Testing of Fertilizer Metering Device. Unpublished Project Report, RSc. Agril. Engg., Allahabad Agricultural Institute, ALLAHABAD, U.P. (India).

Shukla, L.N., Chauhan, A.M., Dhaliwal, L.S. and Verma, S.R. (1987). Field evaluation of rotary blade till attachment for direct sowing operation. *J. agric. Engg. ISAE,* **24** (1) : 21-27.

Verma, H.N. (1982). Selection of seed drill for dry land farmers of Punjab. *Agric. Engg. Today,* **6** (1) : 43-45.

***