RESEARCH ARTICLE

PERFORMANCE EVALUATION OF TRACTOR DRAWN MULTI CROP INCLINED PLATE PLANTER FOR MAIZE (*ZEA MAYS L*)

Manisha Sahu*, Ajay Verma and A.K. Dave

Department of Farm Machinery and Power Engineering, SVAET&RS, FAE, IGKV Raipur (C.G.), Pincode: 492012
Email: sahumanisha79@gmail.com

Received-12.04.2017, Revised-26.04.2017

Abstract: Five row tractor drawn multi-crop inclined plate planter was developed at I.G.A.U., Raipur for sowing of different crops. The calibration of seed and fertilizer rate was done in the laboratory of SVCAET & RS, IGAU Raipur. The seed rate was found 20.13 kg/ha for maize crop (45 cm×30 cm) and fertilizer rate was found from 9.24 kg/ha to 124.43 kg/ha. The field capacity was 0.70 ha/h and field efficiency was 80%. The plant population was found 9-12 plants per square meter. The cost of sowing per hactare was 2 times economical than traditonal method.

Keywords: Cost economics, Field capacity, Field eficiency, Inclined plate planter, Tractor drawn

INTRODUCTION

Maize (*Zea mays L*) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. In India, maize is the third most important food crops after rice and wheat. There have been large variations in the production of maize in India since Independence. It was only 1.7 million tonnes in 1950-51 which rise to 4.1 million tonnes in 1960-61 and 7.5 million tonnes in 1970-71. According to advance estimate it is cultivated in 8.7 m ha (2010-11) mainly during Kharif season which covers 80% area. Maize which can be used food, feed and industry has a remarkable place among cereals. Maize is an inferior grain which is used both as food and fodder. Its grain provides food and is used for obtaining starch and glucose. Its stalk is fed to cattle. Maize can be grown under varied climatic and soil conditions.

Maize is mainly a rainfed kharif crop which is sown just before the onset of monsoon and is harvested after retreat of the monsoon. In Chhattisgarh it is sowing as both in rabi and kharif crop. It requires 50-100 cm of rainfall and it cannot be grown in areas of more than 100 cm rainfall. This crop usually grows well under temperatures varying from 21°C to 27°C, although it can tolerate temperatures as high as 35°C. 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 enginieering institutions. Tractor drawn inclined plate planter has been developed by IGAU, Raipur. The use of tractor drawn inclined plate planter to increase the grain yield by optimizing the seed rate.

The third important source of farm power is mechanical power that is available through tractors and oil engines. In recent years, diesel engines and tractors have gained considerable popularity in agricultural operations. Tractor drawn implements possess higher working capacity and are operated at higher speeds. These implements need more technical knowledge for operations and maintenance work.

The machine combines their 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 proper depth 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 cultivationand 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 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 angle in soil and come into direct contact of fertilizer within a few days after germination.

Seed metering/placement

Roy (1942) suggested that the planter employing inclined plate 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

*Corresponding Author

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°C was sufficient to ensure free movement of seed through the cell. Sahoo and Shrivastav (2000) results shows that inclined plate metering mechanism of three-row ridger okra planter saving of 76% on cost of operation over manual planting with an average operating speed of 2.27 km/h.

Under ICAR Co-ordinate 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 crops 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 their performances were found to be satisfactory (Devnani, 1982 a).

Under ICAR Co-ordinate 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 (Devnani, 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.

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 auger 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 auger 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 0.15×0.20 m and to facilitate applying urea super granules (USG) during transplanting at recommended rates without damaging the granules. This device is called the row plant spacing (RPS) marker-cum-USG dispenser.

Furrow openers

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

Shukla *et al.* (1987) developed a rotary 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 treatments were studied. Germination count and the yield was comparable to the conventional tillage sowing practices. Saving in time, fuel and production cost over the conventional tillage and sowing practices were 4.33 to 11.33 h/ha, to 50.79 to 70.03 percent and 2.68 to 14 percent, 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-ferilizer 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.

Farmers in the rural areas use machet or sticks to sow different seeds; often times more than the required numbers of the seed are dropped in a hole and covered. Planting seeds through this means is labor-intensive and can be made to benefit considerably from simple mechanization (Baniro et al, 1986). Timeliness of field operation in seed planting has been identified as a major factor increasing the intensity of cropping (Ojha and Michad, 2012). Hence, there is a necessity to mechanize seeding operation. According to Bamgboye and Mofolasayo (2006), the traditional planting method is tedious, causing fatigue and backache due to the longer hours required for careful hand metering of seeds if crowding or bunching is to be avoided. Sowing maize by hand increases production cost as extra man-hours is required for thinning operation as excessive seeds is inevitably sown per hole in addition to drudgeryness and boring nature of the work. It is therefore more profitable to develop a system that will be affordable and easy to maintain which will alleviate these difficulties and thus, increase maize production in the rural areas. Considering above points a tractor drawn inclined plate planter (IGAU 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.

MATERIAL AND METHOD

This chapter deals wth the methodologcal approach followed in the laboratory as we as in actual field for testing of tractor drawn five row inclined plate planter.

Description of fve row multicrop tractor drwan inclined plate planter:

Make: I.G.A.U. Raipur

Power source: 50 HP Tractor
Overall dimension:
Length: 2320 mm
Width: 800 mm
Height: 1100 mm
Seed box: Separate for each furrow
Shape: Semicircular
Length: 250 mm
Width: 190 mm
Fertilizer tank
Shape: Trapezoidal
Length: 2000 mm
Width: Top width= 220 mm
Bottom width= 100 mm
Depth: 200 mm
Rated working width of the machine: 1880 mm
Number of rows: 5
Row to row spacing: 450 mm
Type of furrow openers: Shoe type
Dia of lugged type ground wheel: 450
Type of power transmission: chain and sprocket system
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: 2.5:1
Groun wheel to fertilizer metering mechanism: 2.5:1
Crop suitability: Multicrop planting, maize, sunflower, peageon pea, lentil, wheat gram, pea etc.

Location of the experimental site

The tractor drawn five row inclned plate planter was tested in the actual field of IGAU, Raipur. The soil was loam having 42.4% sand, 35.6% silt and 22% clay. On an average the initial bulk density and infiltration rate was found to be 1.53 gm/cc and 0.25 cm/h.

Experimental procedure

Laboratory testing of machine:

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

Calibration of inclined pate planter:

The procedure of testing the planter for correct seed and fertilizer rate is called calibration of panter. 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 adoopted or calibration of tractor drawn inclined plate panter.

Number of furrow openers in planter = N
Distance between two furrow openers = W
Diameter of drive wheel = D
Working width of the planter = $N \times W$
Distance covered in 10 revolution of drive wheel $= \pi D \times 10$ 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 = $Y/(N \times W \times \pi D \times 10)$ 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 or fertilizer metering system. The seed drop was also verified with the appropriate cell for sowing maize and other crops by similar methods.

Measurement of grain damage

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 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.

$$\%\text{ Damage } = \frac{N_D}{N_T} \times 100 \quad \dots (2)$$

Where

N_D = Total number of seeds
N_T = Total number of damage seeds

Seed uniformity test by sand bed method

Prepare an artificial leveled bed of 25 cm depth from fine sand and of a length of at least 5 m and width equal to the nominal width of planter. Allowed the planter to travel over this bed with furrow openers or seed tube lower to 3 to 5 cm from the top surface of the bed. Observed the number of seeds dropped and the average distance between 2 seeds for each meter of bed length. Repeat the test at least three times.

Field testing of machine

Measurement o 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 20.13 kg/ha for maize seed and 124 kg/ha for fertilizer. For planting maize, a plot size 25×7 m was selected. Speed was 4.0 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:

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

Where
S = Linear speed of travel of machine in km/h
W = Width of operation of machine in meter

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

A = Area of plant, m^2
T = actual time taken to cover the area, h (including losses)

$$\text{Field capacity, \%} = \frac{\text{Actual field capacity}}{\text{Theoretical field capacity}} \times 100$$

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.

RESULT AND DISCUSSION

The results have been presented under following heads:

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 o 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 or 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 covered 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 $= 45$ cm

Area cover by 10 revolution $= 1.80 \times 14.13$
$= 25.34\ m^2$

$25.34\ m^2$ land seed drop 120.4 g

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

Hence seed rate in first calibration = 47.5 kg/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 2.5:1 and seed rate of the planter was brought down to desired level. Calibration of modified seed rate is presented in Table 2.

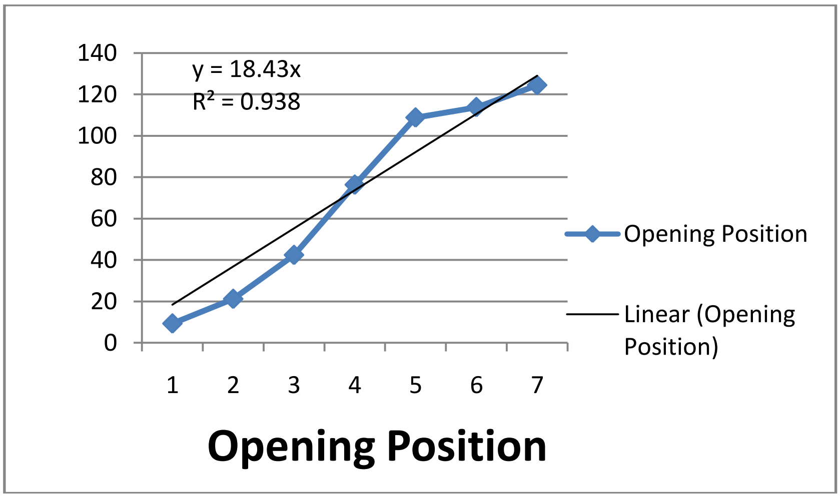

Fig. 1. Calibration curve of inclined plate planter for metering fertilizer

Table 1. First calibration and seed rate

Sr. No.	No. of revolutions	Seed dropping in furrow (g)					Total seed (g)
		I	II	III	IV	V	
1.	10	30	32	34	33	30	159
2.	10	30	28	33	27	25	143
3.	10	25	26	28	28	26	133
4.	10	20	19	18	22	23	102
5.	10	25	23	28	24	30	130
						Average	**133.4**

Table 2. Modified seed rate

Sr. No.	No. of revolutions	Seed dropping in furrow (g)					Total seed (g)
		I	II	III	IV	V	
1.	10	15	12	11	13	10	61
2.	10	12	16	13	12	13	66
3.	10	11	13	14	13	14	65

4.	10	14	10	13	12	13	62
5.	10	14	12	11	14	12	63
						Average	**63.4**

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**	**Furrow opener IV**	**Furrow opener V**	**Total**	
1.	10	0.006	0.002	0.005	0.004	0.002	0.019	9.24
2.	10	0.009	0.020	0.010	0.011	0.012	0.062	21.13
3.	10	0.020	0.017	0.023	0.017	0.011	0.088	42.35
4.	10	0.038	0.035	0.037	0.030	0.031	0.171	76.3
5.	10	0.055	0.050	0.050	0.057	0.057	0.269	108.76
6.	10	0.056	0.051	0.053	0.058	0.059	0.277	113.78
7.	10	0.057	0.053	0.053	0.060	0.060	0.283	124.43

Seed uniformity test by sand bed method: The average distance between two seeds is about 20 to 24 cm which is near to 25 cm recommend plant to plant spacing for maize. 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 45.29 mm.

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 20.13 kg/ha, fertilizer rate 124 kg/ha and row to row spacing 45 cm. 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.

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 0.70 ha/h and 0.87 ha/h, respectively and field efficiencies were calculated as 80 %.

Economics of use of machine:
The cost analysis for use of multi crop inclined plate planter with tractor and fluted roller seed drill were calculated. The cost of sowing with the tractor drawn planter was found to be □ 378/h whereas with fluted roller seed rill by placing seed and fertilizer behind the plough was found to be only □ 498/h. The actual field capacity of the tractor drawn inclined planter and fluted roller seed drill was 0.70 ha/h and 0.45 ha/h, respectively. Thus the cost of sowing per hectare with tractor drawn incline planter and fluted roller seed drill was □ 540/ha and □ 1,107/ha, respectively. Therefore, it may be said that sowing with inclined plate planter is 2 times economical than traditional method. In addition to economy, the timely completion of sowing operation as well as enhanced production is an unparallel advantage for the use of planter.

CONCLUSION

This 5 row inclined plate planter is known multi-crop inclined plate planter and developed under IGKV, Raipur for sowing different type of crops. Thus the project was undertaken with the following objectives:

1. To calibrate multi crop planter for seed (maize) and fertilizer metering.
2. To evaluate planter under field condition.
3. To compare the economics of sowing with traditional method.
4. To achieve the above objectives calibration of planter was done in the laboratory for the seed and fertilizer rate. 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 recorded.
5. Based upon above experimentation the following conclusion was drawn out:
6. The inclined plate planter could be easily attached with the tractor
7. The fertilizer rate was found to be from 9.24 kg/ha to 124.43 kg/ha
8. The seed rate was found to be 20.13 kg/ha
9. Plant population was found from 9 to 12 plants per square meter.
10. Row to row distance was 450 mm and plant to plant distance varied from 300 mm.
11. Depth of sowing was 50 mm.

12. Spacing between seed and fertilizer was observed to 41.2 mm.
13. Field capacity and field efficiency of planter were 0.70 ha/h and 80%, respectively.
14. The cost of sowing per hectare with inclined plate planter and fluted roller seed drill was 540 and 1,107, respectively. Therefore, it may be said the sowing with tractor drawn five row inclined plate planter is 2 times economical than traditional.

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

ACKNOWLEDGEMENT

The authors are thankful to the Niche Area of Excellence FMIR for funding the project, SVCAET & RS, Faculty of Agricultural Engineering, IGKV University, Raipur, for providing the necessary facilities during the research work.

REFERENCES

Bamgboye, A.I and Mofolasayo, A.S. (2006). Performance evaluation of a Two-row Okra planter". Agricultural engineering international: The CIGR E journal. Manuscript pm 06002. Vol viii. July 2006.

Bamiro, O.A, Nuradeen, A and Akuru, I.O. (1986). Introductory technology for schools and colleges. Evans brothers (Nigeria publishers) limited. 227-233.

Bernacki, H. (1972). Agricultural machines, theory and construction. National Technical Information Service, U.S. Department of Commerece, U.S.A. 1.

Devnani, R.S. (1982a). Jyoti planterfor Tamilnadu, Agricultural Engineering Today, 6 (4): 36-38.

Devnani, R.S. (1982b). Seed-cum-fertilizer drill-cum-planter (for Punjab). Agricultural Engineering 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 Mechanization in Asia, Africa & Latin America, 21 (2): 17-20.

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

Ojha, T.P. and Micheal, A.M. (2012). Principles of Agricultural Engineering. Jain brothers East Park Road, Koral Bagh. New Delhi. Sixth Edition.

Sahoo P and Shrivastav A.P. (2000). Development and performance evaluation of okra planter. Journal of Agricultural Engineering vol.37issue (2): 15-25.

Sethi, C.P. and Prqakash, 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. Journal of agricultural Engineering. ISAE, 24 (1): 21-27.

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