Int.J.Curr.Microbiol.App.Sci (2018) *7*(6): 931-940

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 7 Number 06 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.706.111

Design of Manually Operated Multi-Crop Inclined Plate Planter for Farm Women

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Keywords

Multi-Crop, Inclined plate planter, Farm women

Article Info

Accepted:
06 May 2018
Available Online:
10 June 2018

A B S T R A C T

A manually operated multi crop inclined plate planter was designed and its performance evaluated for planting of Maize, Pigeon pea, Bengal gram, Green gram. Power was transmitted from the drive wheel to metering mechanism through chain and multi sprockets and bevel gears. Inclined plate type metering mechanism was used in the planter. Seeds were placed in the furrows at desired depth and seed to seed spacing through adjustable system. The average Depth of Maize, Pigeon Pea, Bengal gram and Green gram was 4.6, 3.83, 4.17 and 4.21 cm and seed to seed spacing was 22.7, 19.2, 12.6 and 11.47 cm respectively. the multi crop planter at an average forward speed of 2.7km.h^{-1} for planting Maize, Pigeon Pea, Bengal gram and Green gram and field efficiency for Maize, Pigeon Pea, Bengal gram. The handle was designed adjustable for the different height of person women and men which can adjust according to own height which reduced drudgery. The adjustable handle helps the operator to push the planter at the time of operation. The adjustable handle length was a 148cm and 40cm of mild steel round bar was bolted inside of the hallow M.S pipe. The cost of the manually operated multi crop planter was approximately rupees 4460 this is the within buying capacity of the formers of the India.

Introduction

In India Agriculture is an important and largest employer sector of the Indian economy, accounting for 7.1 % of the nation's GDP (Gross Domestic Product) and about 49% of the total work force in (2013-2014).

Agriculture in India is generally 30% to50% of the highest average yield in the world. The states of Uttar Pradesh, Punjab, Haryana, Andhra Pradesh, Telangana, Madhya Pradesh, Bihar, Gujarat, Maharashtra are key contributors to Indian agriculture. There was a record food grains production of 251.6 million tonnes during 2015-16 (FAO, 2016), and estimated for next year 2016-2017 is 8% higher than 2015-2016 (i.e., 272million tonnes). The productivity of farms depends greatly on the availability and judicious use of farm power by the farmers. Under intensive cropping, timeliness of operations is one of the most important factors which can only be achieved, if appropriate use of agricultural machines is advocated (Salokhe and Oida, 2003).

Sowing is one of the most important operations in crop production but traditional method of sowing is not suitable for growing the crop. Seeds like Pigeon pea, Green gram, Bengal gram, Black gram, sorghum, maize, sunflower, soybeans and cotton require precision planting. Most of the farmers in India use traditional methods for sowing such as broad casting and seed dropping behind the plough due to undulating topography, small land holdings and higher cost of equipment which effects germination due to non-uniform placement of seeds at proper depth. It is found that the cost of sowing is second after the harvesting in cost of cultivation. Although many planters having different seed metering mechanisms i.e. cup feed type and roller with cells on periphery for the application of single seed at a time has been developed, but it causes Mechanical damage of seed.

Women are also the backbone of the development of rural and national economics these comprise 43% of the world's agricultural labor force which rises to 70% in some countries. In Africa 80% of agricultural production comes from small farmers who are mostly rural women, like that in India also women are the backbone of agricultural they are doing all farm operations in field. So for reducing drudgery in farm operations women operated machines are introducing like less weight machines and handle length adjustable planters.

Hence the manually operated multi crop inclined plate planter is designed then it must have follow Seed metering plate has low cost and it's beneficial for small and marginal farmers, they can easily purchase it, easy to operate both male and female can be operated, Multi teeth sprocket is available in planter for changing the seed to seed spacing according to crop, Easy to change of seed metering plate, Handle can adjust according to operator height, Adjustable furrow opener for control depth of sowing of seed according to crops, Slippage percentage is less because lugs also provides on front wheel of planter

Considering the above factors and need of small farm mechanization, the present study on Design of Multi- Crop Inclined Plate Planter has been taken upto meet the challenges of higher seed rate, sowing seed at uniform depth, to reduce cost of sowing and reduce the drudgery of women by using adjustable handle.

Materials and Methods

A manually operated single row multi crop inclined plate planter was designed at Department of Farm machinery and Power, Vaugh Institute of Agricultural Engineering and Technology, Sam Higginbottom University of Agricultural, Technology and Sciences (Formerly Allahabad Agricultural Institute) Allahabad, Uttar Pradesh. To study the performance evaluation of planter for seeds like Maize, Pigeon pea, Bengal gram and Green gram to compare the economics of operation. The details of materials used, experimental methodology and measurement techniques adopted during the course of investigation were described in this chapter.

Design of inclined plate metering mechanism

The number of grooves on the metering mechanism periphery was calculated using the following formula

$$N_s = \frac{\pi \times D_g}{x \times g_r}$$

Where,

N_s = Number of grooves on the surface
D_g = Diameter of ground wheel, cm.
x = Linear spacing of seeds on ground, cm

g_r = Gear ratio.

Gear ratio was determined using the following formula

$$g_r = \frac{\text{No.of teeth on metering shaft}}{\text{No.of teeth on ground wheel shaft}}$$

Number of teeth on ground wheel shaft = 18

Number of teeth on Multi sprocket = 28, 25, 20, 17, 14

Number of teeth on metering shaft = 44

Number of teeth on bevel gear = 13

The diameter of the ground wheel is 45.5 cm

Similarly it was calculated for different crops

Design of power transmission system

The chain length was calculated using the following formula (Sharma and Mukesh, 2010)

L = m x p

Where,

L = length of chain, cm
m = number of chain links
P= chain pitch, cm

The number of chain links was determined using the following formula

$$m = \frac{2c}{p} + \frac{(Z_1+Z_2)}{2} + \frac{(Z_2-Z_1)^2}{2\pi p}$$

Where,

c = centre to centre distance between two sprockets, cm

Z_1 = number of teeth on driver pulley

Z_2 = number of teeth on driven pulley

Now, the length of chain links was calculated

$$m = \frac{2\times 595}{12.7} + \left(\frac{18+44}{2}\right) + \frac{(44-18)^2}{2\times 3.14\times 12.7}$$

= 133 links

Length of the Chain (mm) $L_c = m \times p$

$L_c = 133 \times 12.7 = 1689.1$ mm or 1.689 m

Design of handle

The adjustable handles of the planter was designed to be adjustable for the different height of person male/female which can adjust according to own height which reduced drudgery. The adjustable handle helps the operator to push the planter at the time of operation (Sharma and Mukesh, 2010). The material was used for adjustable handle of a combination of two mild steel round bar fastened to the frame and mild steel circular pipe. Length of the handle is calculated based on average standing elbow height of female operator. So, the average standing elbow height of women workers is the 100cm.

Distance of wheel centre from the operator (for operator height of 95-105 cm) in operating condition is the 115 cm. In Allahabad average women height of elbow was 88.8 cm. therefore angle of inclination. So, the angle of inclination (θ_h) with the horizontal is

$$\mathrm{Tan}\theta_h = \frac{\text{Height of centre of wheel to the elbow}}{\text{Distance of operation from wheel centre}}$$

$$\tan\theta_h = \frac{88.8}{115} = 0.77$$

$\theta_h = 37.67^\circ$ (It varies 34 to 37^0 because handle is adjustable)

Now, $\sin(\theta_h) = \frac{88.8}{l_h}$ $l_h = \frac{88.8}{\sin 37^{\circ}} = 147.50$cm say 148 cm

Design of shaft

It rotates the seed metering wheel and have ball bearing at the both end of the shaft. The length and diameter of seed metering wheel of shaft was 216 mm and 7 mm respectively. The material was used for the design mild steel.

Testing of planter

Laboratory testing

Calibration of inclined plate planter

The procedure of testing the planter for correct seed rate is called calibration of planter.

$$\text{Seed rate (kg/ha)} = \frac{\text{Seeds obtained by 25 revolution of drive wheel,(g)}}{\text{Width of planter,(m)} \times \text{Circumference of drive wheel,(m)}}$$

Measurement of seed damage

The main aim of this planter is to reduce the seed damage.

The seed damage will affect the germination of the seed and thus the yield of the crop.

$$\text{Seed damage (\%)} = \frac{\text{Weight of damaged seeds}}{\text{Total weight of dropped seeds}} \times 100$$

Field testing

Measurement of seed to seed spacing

Measurement of depth of sowing

Measurement of field capacity and field efficiency

Theoretical field capacity:

$$\text{Theoretical field capacity, ha h}^{-1} = \frac{\text{width (m)} \times \text{speed (km h}^{-1})}{10}$$

Effective Field Capacity:

$$\text{Effective field capacity, ha h}^{-1} = \frac{\text{Total area covered, ha}}{\text{Total time taken, h}}$$

Field efficiency is the ratio of effective field capacity to the theoretical field capacity. It was calculated using the following formula:

$$\text{Field efficiency, \%} = \frac{\text{Effective field capacity, ha h}^{-1}}{\text{Theoretical field capacity, ha h}^{-1}}$$

Results and Discussion

The design and performance evaluation of planter was conducted and results are discussed in the following sections (Table 1–3).

Laboratory performance of planter

The laboratory performance of planter was evaluated for verification of seed drop through respective inclined plates and then it was verified for proper seed rate. The calibration seed rate is shown in Figure 1 (Fig. 1–6). The seed damage due to metering of device was found to be nil.

The seed rate was found to be 15.72, 10.73, 51.21 and 13.36 kg ha^{-1} for Maize, Pigeon pea, Bengal gram and Green gram respectively. The high seed rate of Bengal gram was obtained due size of the seed and spacing between the plants.

Field capacity and field efficiency of planter

The effective field capacity of planter calculated as 0.145 ha h^{-1}, 0.234 ha h^{-1}, 0.075 and 0.0742 ha h^{-1} for crops Maize, Pigeon pea, Bengal gram, Green gram and theoretical field capacity was 0.160 ha h^{-1}, 0.240 ha h^{-1}, 0.08 ha h^{-1} and 0.08 ha h^{-1} respectively and field efficiency were calculated as 91.57 %, 93.45 %, 93.32 % and92.83 % for Maize, Pigeon pea, Bengal gram, Green gram respectively.

Cost of operation of planter

The total cost of fabrication of planter is found to be Rs.4460 and the manually operated multi crop inclined plate planter can save about 94.46% planting cost for crops cultivation.

This multi-crop inclined plate planter for sowing different type of crops.

Thus the project was undertaken with the following objectives:

To design multi crop inclined pate planter

To calibrate multi crop inclined plate planter for seed (maize, pigeon pea, bengal gram and green gram) metering.

To achieve the above objectives calibration of planter was done in the laboratory for the seed rate. Wheel skid, depth, seed to seed spacing, seed damage and field capacity and field efficiency were measured in actual field condition for maize, pigeon pea, bengal gram and green gram crops.

Based upon above experimentation the following conclusion was:-

The diameter of inclined metering plate was 12 cm.

The number of cells on periphery of seed metering plate was found to be 20 for Maize, Pigeon Pea, Bengal gram and Green gram respectively.

Speed of ground wheel was 22.33 r.p.m.

Working width of manually operated planter for Maize, Pigeon Pea, Bengal gram and Green gram was 60, 90, 30, 30 cm.

Fig.1 Line diagram of manually operated inclined plate planter

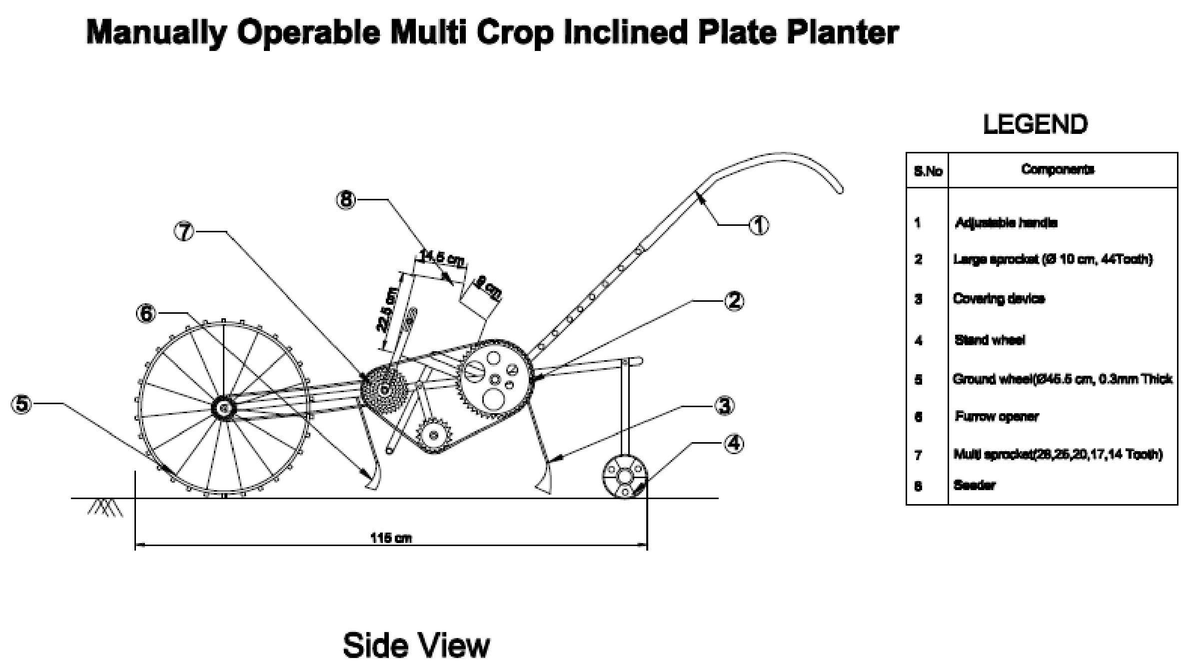

Fig.2 Inclined plate metering mechanism for planter

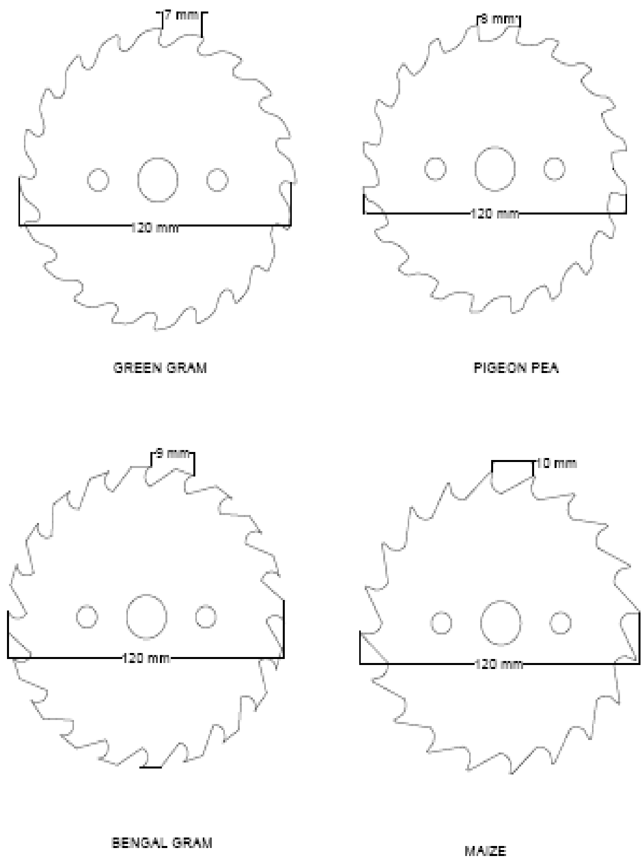

Fig.3 Flow diagram of power transmission system of a manually operated multi-crop inclined plate planter

Fig.4 Flow chart of power transmission system of a manually operated multi-crop inclined plate planter

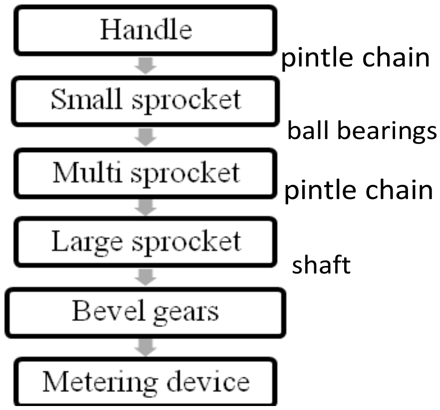

Fig.5 Handle of the planter

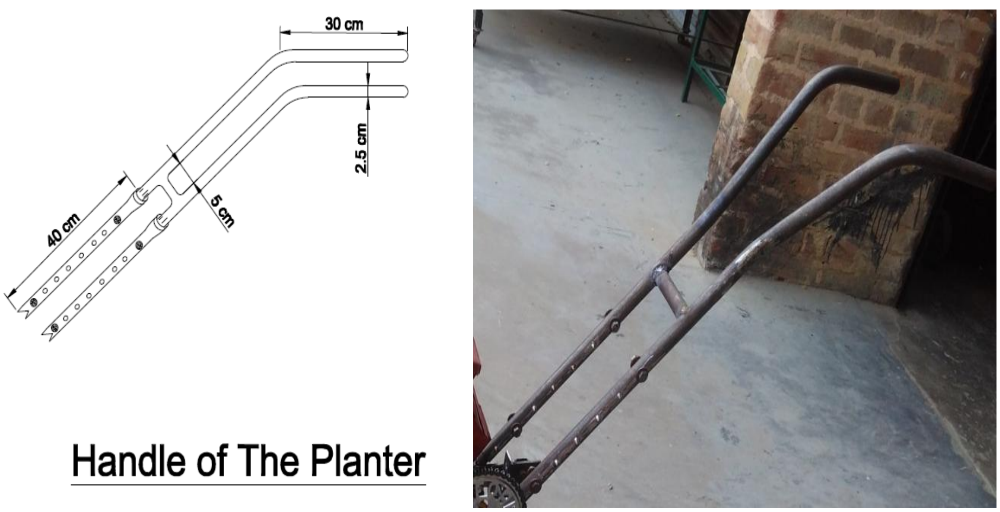

Fig.6 Metering shaft with ball bearings and small sprocket

Table.1 Specifications of the planter

Sl. No	Parameter	Specifications
1.	Length	150 cm
2.	Height	100 cm
3.	Width	20 cm
4.	Furrow opener	Shoe type
5.	Seed metering device	Inclined plates, 20 cells on each inclined plate,12 cm dia.
6.	Runner wheel	45.5 cm diameter
7.	Nut & bolts	20 number
8.	Seed hopper	22.5cm height, 14.5cm bottom width, 23.5cm top width and 17cm height between hopper edges
9.	Seed tube	2.5 cm Outside diameter and length adjustable
10.	Power transmission	Chain, Multi teeth sprocket, small sprocket, large sprocket
11.	Weight	20kg

Table.2 Design of metering plate

Crop	No. of teeth on driving sprocket	No. of teeth on driven sprocket	Gear ratio	No. of cells in seed metering plate	No. of cells
Green gram	28	44	0.636	$\frac{\pi \times 45.5*}{0.636 \times 11.25}$	19.97~20
Bengal gram	25	44	0.568	$\frac{\pi \times 45.5*}{0.568 \times 12.5}$	20.1~ 20
Pigeon pea	17	44	0.386	$\frac{\pi \times 45.5*}{0.386 \times 18.97}$	19.52 ~ 20
Maize	14	44	0.318	$\frac{\pi \times 45.5*}{0.318 \times 22.4}$	20.06~ 20

* Diameter of ground drive wheel

Table.3 Calibration of manually operated multi-crop planter for multi crop seeds

S.N.	A	B	C	D	E	F
For Maize						
1	Full	33.3	33.7	0.00214	15.72	15.40
2		33.7				
3		34.1				
For Pigeon pea						
1	Full	34.0	34.56	0.00321	10.73	10.623
2		34.5				
3		35.2				
For Bengal gram						
1	Full	52.2	54.87	0.00107	51.21	50.64
2		54.8				
3		57.6				
For Green gram						
1	Full	13.9	14.37	0.00107	13.36	13.23
2		14.1				
3		14.8				

*A) Hopper level
B) Weight of seeds dropped in 25r.p.m. of ground wheel, g
C) Average weight of seeds dropped in 25 r.p.m. of ground wheel, g
D) Area covered in 25 revolutions of ground wheel (ha)
E) Theoretically seed rate (kg/ha)
F) Seed rate (kg/ha) with 2 % missing of seeds

Peripheral length of drive wheel was 1.428m

The number of teeth in small sprocket and large sprocket was 18 and 44 and number of teeth in multi gear and bevel gears was 14, 17, 20, 25, 28 and 13, 13 respectively.

The number of links in chain was 133.

The length of chain was 1.689m.

The average calibrated seed rates of Maize, Pigeon Pea, Bengal gram and Green gram during calibration of manually operated multi-crop planter in lab were found 15.72, 10.73, 51.21 and 13.36 kg/ha respectively.

The average percentages of damaged seeds of Maize, Pigeon Pea, Bengal gram and Green gram during damage test of manually operated multi-crop planter in lab were found to be nil out of 100.

The average seed to seed spacing of Maize, Pigeon Pea, Bengal gram and Green gram was 22.7, 19.2, 12.6 and 11.47 cm respectively.

The average depth of Maize, Pigeon Pea, Bengal gram and Green gram was 4.6, 3.83, 4.17 and 4.21 cm respectively.

The average effective field capacity for Maize, Pigeon Pea, Bengal gram and Green gram was 0.145, 0.234, 0.075 and 0.0742 ha/hr.

The average field efficiency for Maize, Pigeon Pea, Bengal gram and Green gram was 91.57, 93.45, 93.32, 92.83 %.

The manufacturing cost of the developed manually operated multi crop planter was Rs. 4460.

The manually operated multi crop planter can save about 94.46% planting cost for crops cultivation.

The design of manually operated multi crop planter was so simple that it was very easy to fabricate with locally available materials. Its operation was very easy and it required very less power to push. Therefore, one person (male or female) can operate it and also it was easy to adjust the handle of the person short or long (men or women). The fabrication cost of the manually operated multi crop inclined plate planter was low. The cost of the developed manually operated multi crop planter was approximately Rs. 4460. This is within the buying capacity of the farmers of India. So, the overall performance of low cost manually operated multi crop inclined plate planter was satisfactory. A good progress of the work has been made successfully. Therefore, the low cost manually operated multi crop planter may be accepted for demonstration and use.

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How to cite this article:

Nandini, Y., S.C. Moses and Aalam, R.N. 2018. Design of Manually Operated Multi-Crop Inclined Plate Planter for Farm Women. *Int.J.Curr.Microbiol.App.Sci.* 7(06): 931-940.
doi: https://doi.org/10.20546/ijcmas.2018.706.111