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Development of Mini Tractor Drawn Punch Planter for Maize Crop

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ABSTRACT

A mini tractor drawn prototype punch planter for maize crop was designed and fabricated in the work shop of Department of Farm Machinery and Power, College of Agricultural Engineering, Bapatla, Andhra Pradesh. The proto type punch planter was designed and developed on the optimum values of influencing parameters. The idea to put the seed in the hole made by the punching mechanism was identified. The major two mechanisms are involved in this development. The first one is making the hole/punch in the soil and second one is to drop single seed in the holes/punches. The PTO power of mini tractor (18.5 HP) was used to operate the punch planter. Based on the PTO lever and gear combinations 10, 16, 24, 35 and 53 cm punch spacings were obtained. Experiments were conducted at different forward speeds of the tractor and concluded that there is no effect of forward speed on punch spacing. Vertical seed metering mechanism was used to meter the seed.

Key words: *Metering mechanism, PTO lever, Punch planter,*

In manual dibbling method, the seeds are sown in lines with a spacing of 22-25 cm between seeds in the rows which are 60 cm apart. By using the long hoe initially make holes in the field generally by the male labour, after that female labour drop one or two seeds in the previously made holes. This is highly labour consuming practice and also the cost of operation is high compared to other practices.

In machine dibbling, an implement is used for making the holes in the field. These implements are available in different sizes depending on the power source. These implements are operated by medium size tractors as well as mini tractors also. After making the holes by the dibbler in the field the holes are filled with one or two seeds by manually. In this also the cost of operation is high but only little bit difference is that the time taken for making holes is less compared to manual dibbling. Many researchers developed different types of punch planters, among these the punching mechanism was obtained with a rotating wheel with pegs around the circumference of the wheel. (Douglas *et al.* 2011, Jayan and Kumar., 2010, Ismail and Hanify., 2009, Germi *et al.*2009 and Molin., 2002)

Punch planter offers better seeding performance because the soil disturbance is minimum and it maintain correct spacing between punches in a row (Akhtar *et al.,* 2014). Individual seeds are dropped in the punches and left uncovered. Due to natural soil temperature gradient during the day, the air in the hole remains stable and the soil does not dry out. This allows the seed for proper germination. For marginal farm holding farmers mini tractors are very much useful for effective utilization of power. The matching implements to suit mini tractors is the need of the day. The punch planting is conceptually ideal for planting because it disturbs a minimal amount of soil and is useful for crops sensitive to precision spacing, which could result in uniform germination and emergence of seedlings and also No-till drills are not working properly especially in black soils with paddy stubbles.

MATERIAL AND METHODS

Major Components of Punch Planter

The prototype punch planter for mini tractor consists the following two major mechanisms.

1. Punching Mechanism
2. Seeding Mechanism

Development of Punching Mechanism

The punching mechanism in the punch planter converts the rotary motion of the PTO shaft in the tractor into reciprocating motion of the punch rod. The punching mechanism consists following components.

Main frame

The main frame was fabricated with mild steel angulars of 50 x 6 mm, 37 x 6 mm and 25 x 6 mm sizes and mild steel flat of 50 x 6 mm size. The main frame supports the entire transmission systems. The transmission system consists of gear box, shafts, chain and sprockets, supur gears, punch wheels, punch rods and seeding mechanism.

The reduction gearbox was fixed to the main frame with the help of mild steel bolts and nuts of 50 x 9 mm size. The output shaft of the gear box was fixed to the main frame with ball bearings. The punch

wheels along with punch rods are fixed to the main shaft, which is attached to the main frame with the help of bearings and bolts and nuts. The specifications of the materials used for fabrication of main frame and overall dimensions of the main frame are mentioned in Table 1 and 2 respectively.

Table 1. Material used for fabrication of main frame

Material used	Specifications (mm)	Quantity (m)
MS angular	50 x 6	4.98
	37 x 6	3.57
	25 x 6	2.14
MS flat	50 x 6	1
	50 x 8	0.5

Table 2. Overall dimensions of the main frame

Particulars	Size
Length, mm	1220
Width, mm	1100
Height, mm	650

Reduction gear box

Commercially available crown and pinion bevel gear reduction gear box was selected to reduce the speed of the PTO shaft of the tractor with the reduction ratio of 1.85 : 1. The specifications of gear box is mentioned in Table 3 and gear box is shown in Plate 1

Table 3. Specifications of reduction gear box

Parameter	Specification
Type	Crown and pinion bevel gear
Speed reduction ratio	1.85: 1
Input power, kW	11.45
Input speed ranges , rpm	600-900

After gear box the power transmitted through chain & sprocket and spur gear attachment. But while transmitting the power there is no reduction in speed. The main purpose of this spur gear transmission is to change the direction of rotation.

The output shaft from the gear box rotates anti-clock wise direction. But for proper punching with minimum soil disturbance in the field the punch rod has to move along the direction of travel. This occurs

Plate 1. Reduction gear box

Plate 2. Final reduction transmission system (Chain and sprocket) used in punch planter

when the punch wheel rotates in clock wise direction. To obtain the rotation of the punch wheel in clock wise direction, the spur gear transmission system was incorporated in the transmission system between gear box and punch wheel.

Chain and sprocket transmission system

This transmission system is the final speed reduction in the punch planter. The reduction ratio at this stage is calculated as 2.42 : 1. According to this reduction ratio the chain and sprocket transmission system was designed. Single roller chain ISO: 08B number was selected as per the design calculations. The single roller chain and sprocket system is shown in Plate 2

Punch wheel assembly

The punch wheel assembly consists of punch wheel and punch rod. Punch wheel was attached to the shaft with the help of bushes and bolts and nuts. The shaft was supported by two ball bearings. To obtain reciprocating motion to punch rod, punch wheel was fixed at a distance of 60 mm towards circumference from the centre. It consists two mild steel circular discs of 200 mm diameter and 10 mm thickness and a circular ring having 200 mm and 160 mm as outer and inner diameters. The punch rod having a length of 250 mm with 25 x 25 mm square cross section was fixed at the circumference of the circular ring as shown in Plate 3

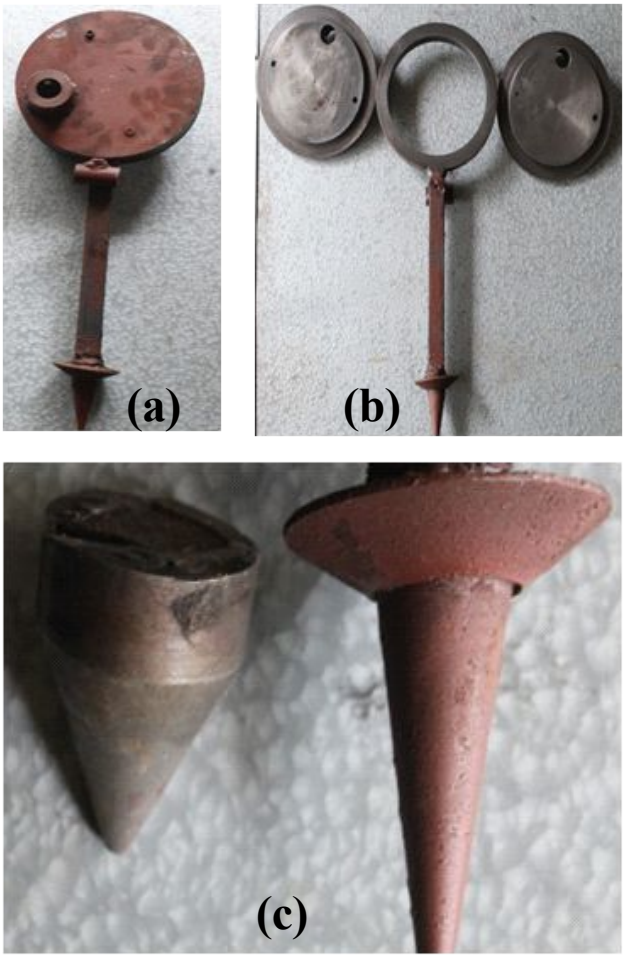

Plate 3. Punch wheel assembly : (a) Punch wheel assembly as a single unit (b) Dismantling of punch wheel assembly and (c) two types of punches

At the end of punch rod, the two shapes of punches were attached. The two shapes of punches were used. While rotating the shaft along with the shaft punch wheel also rotates and produces cam motion. Due to this motion, the punch rod gets reciprocating motion which is required to make holes in the field with a minimum disturbance of soil. Two numbers of punch wheels were fabricated for two rows. Two small helical springs were used to punch rod to restrict lateral movement. The detailed dimensions of punch wheel assembly are tabulated in Table 4.

Table 4. Detailed dimensions of punch wheel assembly

Component	Specification
Circular discs (2 no.)	
Diameter, mm	200
Thickness, mm	10
Diameter of hole, mm	25
Weight of two discs, kg	8.3
Circular ring (1 no.)	
Outer diameter	200
Inner diameter	160
Thickness	20

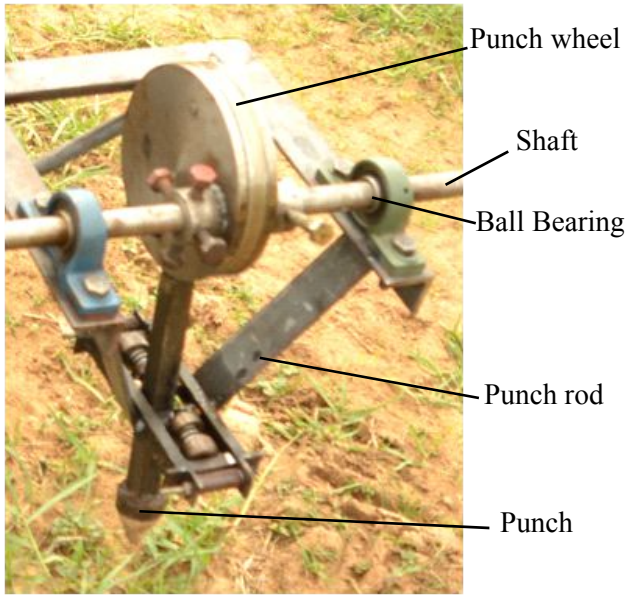

Plate 4. Punch wheel assembly of punch planter

Development of Seeding Mechanism

The punching mechanism in the punch planter makes holes/punches in the soil at desired depth. After that single seed has to be dropped in the hole. This will be achieved by the seeding mechanism. The seeding mechanism in the punch planter consists following components.

1. Seed hopper
2. Vertical seed metering plate
3. Forked wheel and rod assembly
4. Seed dropping tube

1.Seed hopper with vertical seed metering plates

Hopper was designed to cover full width of the machine and located above the main frame. As

per design considerations, single seed boxes were fixed up for individual rows. The cross section of the seed box may be trapezoidal, rectangular, triangular or cylindrical. The bottom was kept usually flat.

The seed hopper was made with 24 gauge galvanized iron sheet of 0.5 mm thickness. The shape of the seed hopper is square on top portion up to a depth of 5 cm and trapezoidal shape at the bottom portion up to a depth of 4.4 cm. The total volume of the hopper is designed as 764 cm^3 , to hold 0.5 kg of maize seed. The physical and mechanical properties of maize seeds were considered while designing the seed hopper.

Vertical seed metering plate

The seed metering mechanism selected for punch planter is vertical seed metering plate. In vertical seed metering mechanism, the seeds are collected and delivered by a series of equally spaced cells on the periphery of a circular plate. The vertical seed metering plate is made up of 90 mm diameter and 10 mm thickness fibre sheet. The disc consists of ten numbers of cells and each cell accommodate a single maize seed.

Forked wheel and rod assembly

The forked wheel and rod assembly is used to rotate the vertical seed plate. In seed plate the cells are pick up single seed from the hopper and drop into the seed tube. The forked wheel is attached to the same shaft of vertical seed metering plate. The vertical seed metering plate and the forked wheel rotate same time with same velocity. The dimensions of the forked wheel and assembly are mentioned in Table 5

Table 5. Dimesions of forked wheel and rod assembly

Component	Specification (mm/no.)
Forked wheel diameter	60
Diameter of centre hole	16
Length of bush	50
No of forks/teeth	10
Base diameter of teeth	6
Length of teeth	4
Forked Rod (square cross section)	12.5 x 12.5
Length of the forked rod	35 + 135 +50+200

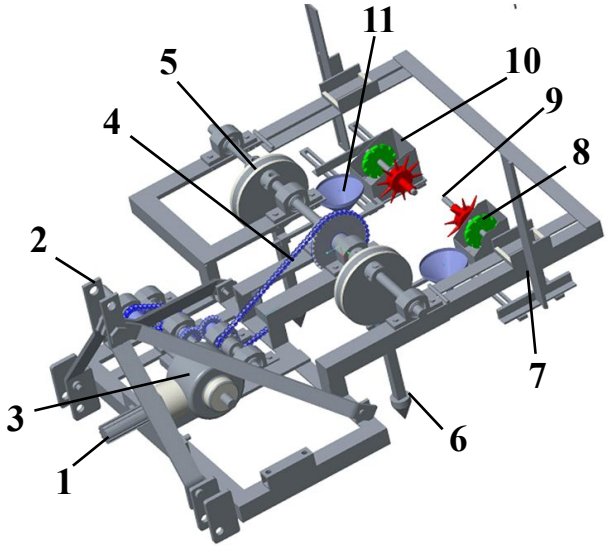

Figure 2. Isometric view of the prototype punch planter

1. Tractor PTO connecting point
2. Three point hitching frame
3. Reduction Gear box
4. Final reduction (chain and sprocket)
5. Punch wheel
6. Punching rod
7. Vertical and horizontal adjustment setup
8. Vertical seed plate
9. Forked wheel and rod assembly
10. Seed hopper
11. Seed dropping tube

RESULTS AND DISCUSSION

Reduction ratios

The speed of the punch wheel was estimated based on seed to seed distance for maize crop. To obtain the correct punch spacing, reduction ratios were calculated. As reduction ratio between Engine Speed and PTO Speed Engine speed increased from 1000 to 2000 rpm, the PTO speed also increased from 223 to 447 rpm, respectively in lever position 1. In lever position 2, it was observed that the speed increased from 315 to 657 rpm with the increase of engine speed.

The average reduction ratios from engine speed to PTO speed for the selected tractor were 4.46 and 3.07 at PTO lever position 1 and position 2, respectively.

Reduction Ratio between PTO to Gear Box Output Shaft.

The PTO speed increased from 223 to 447 rpm, gear box output shaft speed also increased from 120 to 244 rpm at lever position 1, respectively which

gave average reduction ratio of 1.85. In lever position 2, the gear box output shaft speed increased with the increase of PTO speed which gave reduction ratio of 1.84. It was observed in both cases that the reduction ratio from PTO to gear box output shaft is constant. The speeds of PTO shaft and gear box out put shaft along with reduction rations were mentioned in Table 10.

Reduction Ratio between Gear Box Output Shaft to Punch Wheel

In lever position 1, gear box output shaft speed increased from 120 to 244 rpm, the punch wheel speed also increased from 46 to 87 rpm, respectively, thus obtaining reduction ratio of 2.42. In lever position 2, gear box output shaft speed increased from 174 to 358 rpm and the punch wheel speed also increased from 65 to 129 rpm, respectively obtaining reduction ratio of 2.75.

Overall Reduction Ratios

The reduction ratios at two lever positions from engine to PTO were 4.46 and 3.07 for lever position 1 and 2, respectively. Fixed reduction ratios of 1.85 and 2.75 were obtained between PTO shaft to gear box and gear box output shaft to punch wheel shaft, respectively.

It showed that the overall reduction ratios from engine to punch wheel are 22.61 and 15.53 for PTO lever position 1 and 2, respectively (Table 6)

Table 6. Overall reduction ratios from engine speed to punch wheel speed at different stages

Type of reduction	Reduction ratio	
	At PTO lever position 1	At PTO lever position 2
Engine to PTO shaft	4.46	3.07
PTO shaft to Gear box out put shaft	1.85	1.84
Gear box out put shaft to Punch wheel shaft	2.42	2.42
Engine speed to Punch wheel shaft	19.96	13.67

Effect of Gear and PTO Lever Selection on Punch Spacing

The average punch spacing of 10, 16, 24, 35, 53 cm were obtained in different gear and PTO lever positions. Punch spacing was constant in particular gear and PTO lever position. The punch spacing was obtained in PTO lever position 1 and varying gear positions 1,2 and 3 are 16, 24 and 53 cm respectively and punch spacing was obtained in PTO lever position 2 and varying gear positions 1,2 and 3 are 10, 16 and 35 cm, respectively (Figure 5).

Table 7. Punch spacing at different forward speed of the tractor in PTO position 2

Lever and gear position	Forward speed (kmh^{-1})	Punch spacing (cm)
P2G1	0.35	10.82
	0.39	10.6
	0.53	10.54
	0.59	10.4
	0.69	10.4
	0.83	10.1
	0.92	10.3
	0.96	10.1
	0.99	9.9
P2G2	0.85	16.2
	0.93	16.06
	0.98	16.1
	1.13	16.06
	1.28	16.2
	1.56	16.24
	1.71	16.24
		16.1
	1.68	
P2G3	1.75	35.64
	2.01	35.68
	2.47	35.4
	2.77	35.7
	2.88	34.9
	3.14	35.3
	3.5	35.4

In particular gear and PTO lever position, forward speed of the tractor increased with increasing engine speed. But there was no effect on punch spacing in particular gears and PTO selection. The required punch spacing can be obtained by selecting the gear and PTO lever. The forward speed of the tractor was obtained from 0.35 to 3.28 kmh^{-1}.

Effect of Forward Speed on Punch Spacing

At particular PTO and gear selection the punch to punch spacing maintained constantly even though the forward speed increased. This is due to increase in engine speed increases PTO speed and thus increasing forward speed proportionally.

PTO Lever Position 2 and Three Gear Combinations

Different forwards of the tractor obtained by increasing the engine speed from 800 to 2400 rpm in each gear selection. Maximum forward speed of 3.50 kmh^{-1} obtained in gear 3 (G3) followed by 1.68 kmp^{-1} and 0.99 kmh^{-1} in gear 2 and gear1, respectively. It was observed that PTO lever position would affect the forward speed of the tractor but affects the punch spacing.

In a particular PTO lever position (P2) with the combination of gear selection, three different punch spacing were obtained. In each combination (P2G1, P2G2 and P2G3) even though forward speed increased, there was no significant effect on punch spacing.

CONCLUSION

Punch planter was designed and developed for sowing of maize seed. The average punch spacing of 10, 16, 24, 35 and 53 cm was obtained in different gear and PTO lever positions. There was no significant effect on punch spacing in a particular gear and PTO lever position with forward speed of the tractor. The required punch spacing can be obtained by selecting the gear and PTO lever position and the forward speed of the tractor can be maintained between 0.35 to 3.28 kmh^{-1}.

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