



Design and Development of a Two-row Power Operated Maize Dibbler

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Seed sowing is an essential and time-bound process agriculture. The basic objective of the sowing operation is to put the seed in rows at the desired depth and maintain seed to seed spacing, covering the seeds with soil and providing proper compaction over the seed. Early or postponed sowing adversely disturbs the crop yield. Therefore, the sowing of seeds in the optimum level is important to ensure more outcomes and high quality of crops. At present, the maize planting is done manually by broadcasting, dibbling, putting seed behind the plough, and other methods or with the help of animal or tractor-drawn seed drills/planters. Though, these techniques have many problems, such as worse efficiency and reduced quality seed placement. Currently among different sowing methods, dibbler planter delivers more uniform and adaptable seed spacing than other approaches for sowing hybrid seeds. But available dibbler planter has some shortcomings of lower field capacity. By considering the apparent advantage of the dibbler planter mechanism, the power-operated dibbler planter for pulse crop was modified and improved to minimize the problems of the

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existing dibbler planter. Henceforth, the two-row power-operated dibbler was designed and developed to promote mechanization of maize planting operation among small and marginal farmers.

Keywords: Dibbler; maize; mechanization; planting; seed.

1. INTRODUCTION

Maize (*Zea mays L.*) is one of the staple food grains after rice and wheat. Globally, maize is the queen of cereals because it has the highest genetic yield potential. In India, predominant maize cultivating states are Madhya Pradesh and Karnataka has highest area under maize (15% each) followed by Maharashtra (10%), Rajasthan (9%), Uttar Pradesh (8%) and others [1].

In Tamil Nadu, it is cultivated in 0.40 million hectares and 2.72 million tonnes of production during 2020-2021. The major maize growing districts of Tamil Nadu are Salem, Dindigul, Namakkal, Pudukottai, Tiruppur, Villupuram, Perambalur, and Ariyalur [1]. Costly hybrid seeds and complicated planting methods highly dominate maize cultivation. Inappropriate planting methods caused a reduction in germination, growth, and development and increased susceptibility to disease and lodging [2]. Also, the lack of agricultural labour leads to an increase in production cost; therefore, mechanization represents an essential factor in reducing costs and increasing productivity [3]. The mechanical so funny stop devices in traditional seed drills are not capable of functioning at high forward speed (Kumar, 2000). Dibbling is one of the oldest method of sowing seeds to maintain proper spacing and planting depth. Proper placement of seeds is essential for high return and high quality of crops. Thus, for higher productivity, the metering unit should be precise to plant seeds to the necessary seed distance on a row without repetition and absent as they affect the yield. In the conventional method of sowing, the non-uniform plant population adversely affects the grain yield of different crops [4,5]. CIAE seed drill, Naveen dibbler, manual oilseed drill, and manual multi-crop planter/garlic planter were suitable for sowing small to large seeds like wheat, soybean, maize, gram, pigeon pea, green gram, garlic,

peas, and groundnut [4]. Seeds must be placed at equal intervals within rows. Among the traditional sowing methods, precision sowing is preferred as it provides more uniform seed spacing. The correct placement of seed ensures saving in costly seeds, reduction in the problem of precision seeding, and results in higher crop yield [6]. The plant to plant distance is influenced by several factors, including variability of seed metering unit and seed dropping. Through constant spacing, the roots can grow to a uniform size [7]. Therefore, to obtain maximum yields, seeds should be planted at the chosen spacing and in such a way that all viable seeds germinate and develop quickly [8]. The interaction between seed size/shape, planting depth, and temperature significantly affects the seed emergence percentage and seeding vigor [9]. The performance of planters has remarkable influences on yield in agricultural products, and especially its seeding uniformity is crucial in estimating the seed quality.

2. MATERIALS AND METHODS

2.1 Seed Parameters

Physical properties such as length, breadth, thickness, roundness, equivalent diameter, sphericity, seed weight, were considered as design parameters for a dibbler. The sphericity and roundness affect seed movement through the various components of the dibbler. The three significant dimensions such as length (l), breadth (b) and thickness (t) of randomly chosen 100 maize seeds, were measured using digital vernier with an accuracy of 0.01 mm.

The equivalent diameter of the seed was calculated by,

$$\text{Equivalent diameter} = (l \times b \times t)^{1/3}$$

Where: l (length), b (breadth), t (thickness)

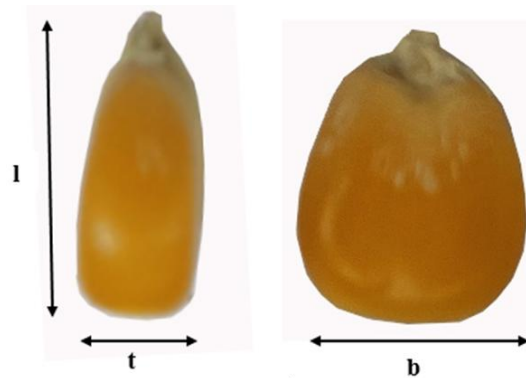


Image 1. Dimensions of a Maize Seed

The sphericity of maize seed was found out by diameter of largest inscribing circle and diameter of smallest circumscribing circle.

$$\text{Sphericity} = D_i/D_c$$

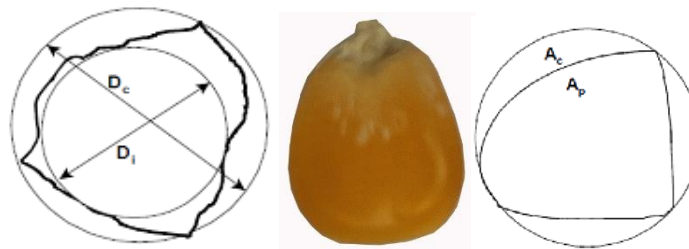


Image 2. Measurement of Sphericity and Roundness

The roundness of seed was found out by projected area of maize seed and area of smallest circumscribed circle.

$$\text{Roundness} = A_p/A_c$$

where: A_p = largest projected area of seed in natural rest position

A_c = area of the smallest circumscribing circle

Table 1. Physical properties of the maize seed

S.No	Parameters	TNAU maize - Co 6	TNAU maize - Co 8
	Length (mm)	10.1±0.2	9.5±0.5
	Thickness (mm)	4.5±0.3	5.3±0.2
	Breadth (mm)	8.5±0.4	7.6±0.2
	Area (mm ²)	71.00±0.14	79.00±0.20
	Roundness	1.14±0.14	1.5±0.6
	Equivalent diameter (mm)	9.50±0.10	10±0.20
	Sphericity		
	Natural Rest position	0.621±0.065	0.615±0.075
	Vertical Position	0.551±0.015	0.531±0.011
	Thousand seed weight (g)	268.30±0.092	272.20±0.083

In various agronomic practices, the planting technique is vital because of the ideal plant population and proper routine of the input resources [10]. It was reported that dibblers provide the desirable plant population with

uniform plant spacing and operation depth, resulting in a uniform crop stand. Hence, a reduced cost of cultivation is achieved due to the elimination of thinning procedures and sowings of seed and fertilizer [11].

2.2 Design and Construction of a Dibbler

The major components of the dibbler are the mainframe, power source, speed reduction unit, hopper, metering unit, seed tube, slider-crank mechanism, power transmission unit, drive wheels, support wheel and handle, as shown in the Fig. 1.

2.3 Main Frame

The mainframe provides the mounting of different machine units, viz. transport wheels, dibbler unit, transmission system, and seed metering and seed hopper. The assembly was made from the square hollow pipe of 40 × 20 × 2 mm. The frame was constructed in a rectangular shape with the help of a mild steel L- angle. Two dibblers were mounted on a long square pipe placed vertically. The dibblers were mounted in such a way as per the row to row and plant to plant spacing of crop requirements. The steering mechanism was also

attached to the mainframe to turn the developed dibbler planter during operation and transportation.

2.4 Dibbling Unit

It is made out of mild steel which is used to punch and create holes in the soil at the desired depth of seed placement. The dibbler unit was fitted on the crank mechanism to move up and down. The dibbler consists of a spring-loaded soil opening cone and plate. The spring is used to forcefully shut the closing plate just after dropping the seed to prevent the dropping of the following seed over the soil surface. The dibbling unit reaches the lower position; it pushes a lever to open the spring-loaded soil opening plates. Subsequently, it facilitates the placement of the seed in the right place. The spring-loaded lever is fitted in such a way that it cannot affect the reversing of the machine.

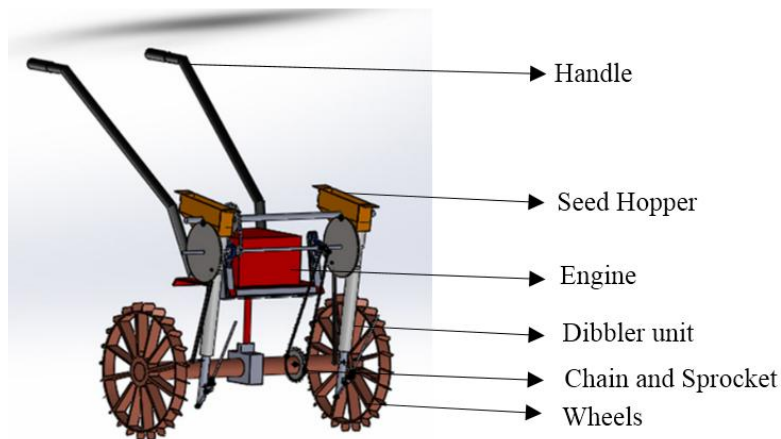


Fig. 1. CAD Design – Dibbler



Fig. 2. Dibbler Unit

2.5 Power Transmission

The power to the slider crankshaft is transmitted from the main shaft through chain and sprocket. The diamond-type chains of 12.5 mm pitch and four sprockets of 12 mm thickness with different number of teeth viz., 42, 32, 14, and 12 were used. The sprocket of 42 teeth was mounted on the ground wheel's shaft from the engine output, the sprocket of 12 and 14 teeth was mounted on the intermediate shaft, and the sprocket with 32 teeth was mounted on a seed metering disc shaft. The power from the engine was transmitted to the seed metering shaft by the shaft to the seed disc in the hopper. It picks and drops to the dibbler through a seed tube.

2.6 Seed Hopper

The performance of seed metering plate was uniform throughout the operation when the seed hopper was maintained with three-fourth of its capacity [12]. A separate trapezoidal shaped seed hopper, made up of ABS plastic was

provided in each dibbler. The capacity of seed hopper was designed to hold one kg of seed. The funnel shape tube was attached to the front side of seed hopper and it was kept inclined at an angle of 30 degree for the betterment of seeds pickup. The seed container also has a control gate to maintain a required flow of the seeds to the seed hopper with a metering device.

2.7 Seed Metering Mechanism

The single cell feed vertical roller metering mechanism was used for the metering of seed. It consists of cups of spoons on the periphery of a vertical rotating disc that picks up the seeds from the hopper and delivers them into the seed tubes. It picks up a few seeds and drops them into small hoppers when the disc rotates. The seed rate is controlled by the size of the cups and the rate at which the dibbler rotates. A plastic-made flexible seed tube of 30 mm diameter is provided below the seed metering unit to transport the seed from the seed hopper to each dibbler in the dibbler unit.

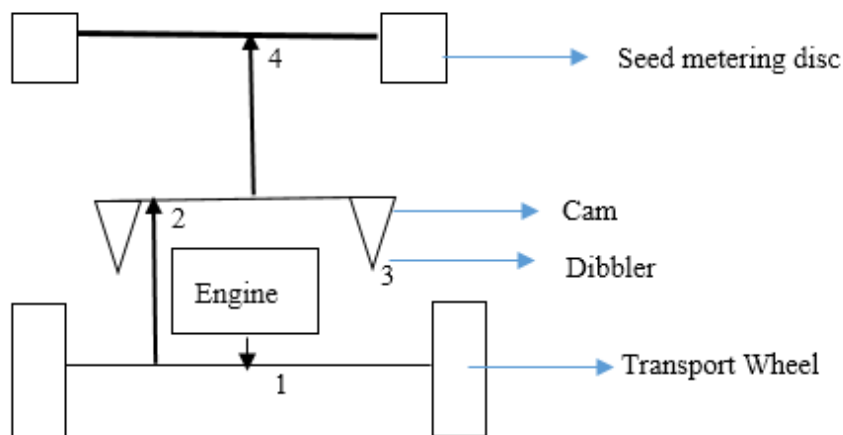


Fig. 3. Power transmission diagram

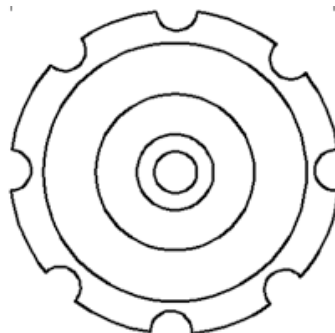


Fig. 4. Vertical roller metering mechanism



Fig. 5. Prototype two row maize dibbler

Table 2. Specifications of the two row power operated dibbler

Sl. No.	Component	Specifications
	Engine	Two stroke single cylinder 1.54 kW petrol engine
	Fuel tank capacity	2 litre
	Speed (rpm)	3000
	Mechanism	Slider crank
	Power Transmission	Chain and sprocket
	Speed Reduction	1:5
	Transport Wheel	2 wheels of diameter 460mm
	Seed metering unit	Vertical/inclined plate metering mechanism
	Number of seed hopper	Two
	Plant spacing	15 -30 cm (adjustable)
	Row Spacing	60 -90 cm (adjustable)
	Number of rows	Two

The vertical roller type metering mechanism was intended based on the physical properties of the maize seed, as shown in Table 1. The thickness and cell geometry of the seed metering discs were designed in reference to the maximum breadth and length of seeds [13].

2.8 Transport Wheels

The lugged iron wheels are provided on the frame apart from the centre on either side of the frame, forming the functional component for operating without any slip. The ground wheel was made from four MS flat 460 mm diameter and 5 mm thickness. The spokes of the wheel were made of 25 mm thick mild steel flat. On the periphery of the ground wheel, 20 number of lugs (MS plate - 25 x 25 x 4 mm) welded equidistantly to create better traction on the soil. The specifications of the dibbler were presented in Table 2.

3. CONCLUSION

The size of the land holdings has implications for investments in agriculture, productivity, farm mechanization and sustaining farm incomes. Labour requirement in different maize growing states ranges between 431 to 753 man hour per ha in India, which contribute approximately 39-64 percent of total operational cost [14]. With the consideration of reducing the utilization of man hour in maize cultivation, the dibbler was designed. The dibbler was able to meter one seed per hole with a negligible percentage of damaged seeds. It gives a great and improved precision planting of maize on rows per stand at low seed loss. An average local farmer appreciates the simplicity of operation and ease of maintenance [15,16]. Hence adoption of mechanization in sowing of maize seeds can potentially reduce the requirement of labour and reduce the production cost.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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