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Analysis of inclined plate metering mechanism for direct seeded rice

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Abstract
The metering device was tested in all three inclination angle and four gear ratio viz. 50°, 60°, 70° and 1: 1, 1.31:1, 1.57:1 and 1.94:1 respectively. The results of lab test shows that the seed rate increase with decreasing the angle of inclination of metering plate and also increasing with decreasing gear ratio for all thirteen varieties of paddy. The laboratory studies revealed that about 20 – 25 kg/ha seeds rate should be obtain at an angle of 60° and in gear G3 (1.57:1 gear ratio) and G4 (1.94:1 gear ratio) for all the thirteen varieties of paddy. The seed damage in inclined plate planter was negligible. Based on the laboratory test 50° and 60° inclination angle of metering plate, and gear G3(1.57:1 gear ratio) and G4(1.94:1 gear ratio) and forward speed of 4.5 km/h was selected for field testing on the inclined plate planter. The performance of the inclined metering device was found to be satisfactory in the field for all thirteen varieties of paddy. Average seed rate of one varieties namely R1 (Rajeshwari) of paddy was about 20-30kg/ha which is 50% less than the line sowing by fluted roller seed drill. The average miss index, multiple index and plant population/m^2 for two varieties was found to be only 5.3%, 8.2% and 68 plant/m^2, respectively, which was within acceptable limit.

Keywords: Inclined metering plate, speed ratio, angle of inclination, rotor speed, seed rate

Introduction
Tractor mounted 9-row inclined plate planter is a multi-crop planter for planting of bold and small seeds which cannot be sown satisfactorily by conventional seed drills. Rice is a most prominent crop in India and is the staple food fulfilling 43% of the caloric requirement of a majority of the Indian population. The production of rice in India was 105482.1 thousand tonnes in 2014-15. It decreased by 1163.4 thousand tonnes in 2014-15. Chhattisgarh is popularly recognized as the rice bowl of the country as rice is the principal crop of this state and about 69.7 per cent of net sown area is covered under *kharif* rice. Chhattisgarh state has 7th rank for rice production to 60.28 Lakh Tonnes in all over India (Anonymous, 2015). Direct sowing of rice is an ancient practice of rice cultivation in India, particularly in rain-fed areas, where farmers totally eliminate the seedling preparation in nursery and transplanting. In rain-fed and deep water ecosystems, dry seed is manually broadcast onto the soil surface and then incorporated either by ploughing or by harrowing while the soil is still dry. Dry seeding of rice can be done by drilling the seed into a fine seedbed at a depth of 2-3 centimeters. The direct sown paddy saves about 25 percent irrigation water as it avoids puddling and enhanced irrigation intervals. There was a net saving of Rs. 13,000/ha in crop establishment due to direct sown paddy as against the conventional puddled transplanted rice (Singh, 2014).
The Planter consists of a frame with tool bar, modular seed boxes; furrow openers and ground drive wheel system. Seed plates for sowing different seeds can be selected and easily changed. The plate thickness, number and size of cells on seed plate vary according to seed size and desired plant-to–plant spacing. Shoe type furrow openers ensure deeper seed placement in moist zone for sowing under dry land conditions. Modular seed box-furrow opener units are adjustable for sowing seeds at different row-to-row spacing. Drive to seed metering mechanism is transmitted from ground drive wheel through chain and sprockets. Drive ratio between ground drive wheel and seed plate can be changed, by selecting appropriate size of sprocket on wheel axle or on counter and main drive shafts. Seeds are filled in the first compartment of seed box. Flow of seeds to seed metering compartment is controlled through the adjustable opening so as to keep the seed level in metering compartment up to centre of seed plate for effective picking of seeds. With zero till ferti-drill sowing, the optimum seed rates for fine grains, basmati cultivars is 15-20 kg/ha, coarse grains 20-25 kg/ha and for hybrids 8-10 kg/ha. Use of planters having inclined plate devices or a cupped metering system is very useful for proper spacing (20 cm) and reducing seed rate. For broadcasting a higher seed rate (25-30 kg/ha) is required. Seeding depth plays key role for good germination. Depth should not be kept more than 3 cm for desired level of crop stand.

Placement of seeds below 3 cm adversely affects dynamics of seed emergence because of rapid drying of the upper layer soil moisture.Simultaneously, the availability of high-yielding, short-duration varieties, and chemical weed control methods made such a switch technically viable. This technique reduces labor needs, input requirements, investment and save time by timely sowing of rice and shorten crop duration by 7–10 days than transplanted rice.

Materials and Methods

Laboratory testing of machine. All the moving components of the machine were lubricated properly. It was then calibrated for Proper seed rate.

Calibration of inclined plate planter

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

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

The step by step procedure shall be as follows:

a) Determine the nominal width of coverage of the drill. The nominal width is equal to the multiplication of the number of furrow openers (N) and the spacing between the openers (W) in cm. Working width of the planter = N x W

b) Find the length of a strip, having the nominal width as determined in (a) above, necessary to make one hectare;

c) Determine the number of revolutions the ground wheel has to make to cover the length of the strip determined in (b) above. It is recommended that this should be done by actually operating the drill in the same field and soil conditions as will be used for the field operation test. Distance covered in 1 revolution of ground wheel = π D m

d) From the value found in (c) above, select a number of revolutions of the ground wheel to cover a convenient fraction of a hectare, say, 1hac. A drill having a nominal width of 1.8 m and ground wheel diameter of 42 cm will require about 4421 revolutions to cover 1 hectare.

$$\text{Formula} = \frac{10000}{\pi \times D \times N \times W}$$

e) Calculate revolutions per minute of ground wheel in case of animal drawn drill and revolutions per minute of metering device in case of tractor-drawn drill. The travelling speed for animal drawn drill should be 2.4 km/h and for tractor drawn drill the speed should be 3 and 5 km/h. A 60-cm diameter wheel makes about 21 revolutions per minute when travelling at a speed of 2-4 km/h.

f) Jack up the drill so that the ground wheels turn freely. Make a mark on the drive wheel and a corresponding mark at a convenient place on the body of the drill to help in counting the revolutions of the drive wheel. Practise turning the wheel at the speed calculated in (e) above, if turning has to be done manually for animal-drawn drill.

g) Select the seed = Paddy seeds.

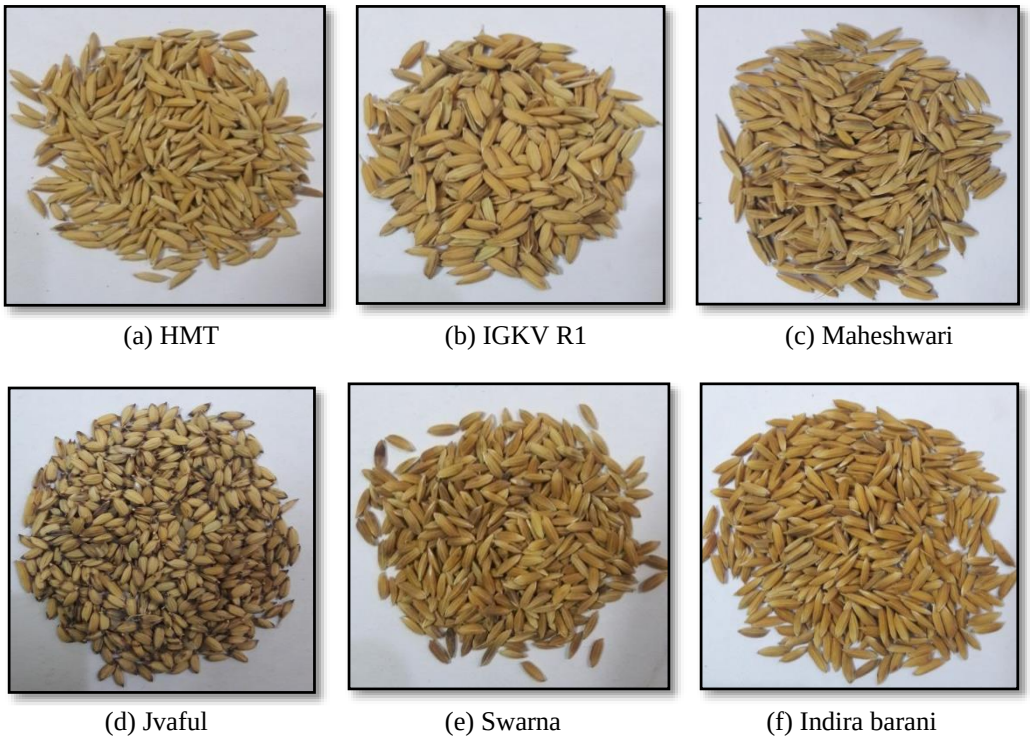
h) Put selected seed and fertilizer in the hopper. Place a sack or container under each boot.

i) Rotate drive wheel at the speed as calculated in (e) above.

j) Weigh the quantity of seed dropped from each opener and record on the data sheet.

k) Calculate the seed dropped in kg/hectare and record on the data sheet.

l) Repeat the process indicated in (h) to (k) at least three times.



(a) HMT (b) IGKV R1 (c) Maheshwari

(d) Jvaful (e) Swarna (f) Indira barani

Fig 1: Paddy seeds used for evaluation of metering mechanism

Measurement of grain damage
Five revolution of ground wheel was given and weight of seed dropped was calculated. The following relationship was used for calculation of seed damage.

$$\% \text{ Damage} = N_T / N_D \times 100 \quad \ldots (1)$$

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

Theoretical seed spacing
The theoretical seed spacing in the laboratory was found out by following relationship;

$$Xs = \frac{C \times T_1}{n \times T_2} \quad \ldots..(2)$$

Where,
Xs = Seed to seed spacing.
T1 and T2 = Number of teeth on the ground wheel and the seed plate assembly.
n = Pair of orifices on the seed plate.
C = Circumference of the ground wheel.

Speed ratio
Speed ratio from drive wheel shaft to metering shaft = (No. of teeth on metering shaft (T_M)/ No. of teeth on drive wheel shaft (T_D),

$$\frac{N_D}{N_M} = \frac{T_M}{T_D} \quad \ldots.. (3)$$

Field performance of inclined plate planter
The inclined plate planter was used to evaluate the seeding performance of the inclined seed metering mechanism in the dry pulverized field.
The theoretical field capacity was calculated based on the formula given below:

$$\text{Theoretical field capacity} = \frac{S \times W}{10} \text{ ha/h} \quad \ldots.. (4)$$

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

$$\text{Actual field capacity (ha/h)} = \frac{A}{T \times 10^4} \quad \ldots.. (5)$$

A = Area of plat M^2, T = actual time taken to caver the area, h (including losses)

Field efficiency
From the actual and theoretical field capacity, the field efficiency was calculated (Kepner, *et al*., 1960),

$$\text{Field efficiency (\%)} = \frac{\text{AFC}}{\text{TFC}} \text{ x } 100 \quad \ldots. (6)$$

Measurement of depth and spacing of seed
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.

Missing index (MI)
Skips or misses are created when seed dropping cells fails to drop seeds to the furrow. The missing percentage is presented by an index called the Missing Index (MI) (Bakhtiari and Loghavi, 2009) Smaller values of MI indicate better performance than larger values.

Multiple Index (DI)
Multiples are created when more than two seed is delivered by a cell. The multiples percentage is represented by an index called Multiple Index (DI) (Bakhtiari and Loghavi, 2009) smaller values of DI indicate better performance.

Fig 2: Field evaluations of inclined seed metering mechanism for paddy seeds

Table 1: Plan of experiment on metering device

S. N.	System variable	Parameter consider
1	Varieties of paddy seeds	Mahamaya (V1)
		IR 36 (V2)
		Purnima (V3)
		Danteshwari (V4)
		Karmamasuri (V5)
		Bamleshwari (V6)
		Chandrahashini (V7)
		Swarna (V8)
		Maheshwari (V9)
		IGKV R1 (V10)
		Jvaful (V11)
		Indira Barani (V12)
		HMT (V13)
2	Speed ratio	G1 (19 teeth) = 1: 1
		G2 (25 teeth) = 1.31:1
		G3 (30 teeth) = 1.57:1
		G4 (37 teeth) = 1.94:1
3	Inclination of seed plate to Horizontal	Ø 50°
		Ø 60°
		Ø 70°

Result and Discussion
Effect of inclination angle and different gear speed of inclined metering plate planter on the seed rate
The laboratory performance of machine was evaluated for verification of seed drop through respective rollers. The calibrated seed rate than two to three seed was dropped from the cell at a time. Inclination Angle and Different Gear Speed of Inclined Metering Plate Planter on the Seed Rate are shown in Table 3.5. Distance cover by ground wheel in one revolution

$= \pi$ D = 3.14 x 0.42 = 1.31 m

Distance covered by 20 revolutions = 26.37 m
Row to row distance = 20 cm
Area cover by 20 revolution =1.80 x 26.37 = 47.47 m^2
In 47.47 m^2 land seed drop 91.3 gram
Therefore, 10,000 m^2 land seed drop = 20.4 kg/ha
Hence seed rate in calibration = 20.4 kg/ha

Measurement of Grain Crackage

The average per cent of paddy seeds damage were calculated by collecting seeds along the rows sample after 20 revolution of ground wheel.

The effect of inclination angle and different gear speed of inclined metering plate on the seed damage is given in Table 2.

Table 2: Average seed damage (%) of inclined seed plate planter at different angle of inclination and different speed

Inclination angle	Gear 1	Gear 2	Gear 3	Gear 4
50°	0.17	0.22	0.23	0.37
60°	0.23	0.32	0.34	0.45
70°	0.24	0.26	0.41	0.47
Avg.	0.21	0.27	0.33	0.43
SD	0.03	0.04	0.09	0.05
CV, %	17.48	18.03	27.43	12.56
SE	0.02	0.02	0.05	0.03

Theoretical seed spacing

The theoretical spacing between seed dropped by planter was calculating with the help of the circumference of the ground wheel and the no. of orifice in seed metering plate are shown in Table 3.

Speed ratio

Theoretical Seed Spacing and seed rate in different angle are changed with respect to different gear ratio are shown in Table 3.

Table 3: Theoretical Seed Spacing and seed rate at different gear ratio

S. No.	Types of Gear	Speed Ratio	Theoretical Seed Spacing, cm	Range of Seed Rate of thirteen varieties of paddy, kg/ha		
				50°	60°	70°
1	G1 (19 Teeth)	1:1	9	32.84 – 51.32	25.18 – 42.53	19.87 – 39.55
2	G2 (25 Teeth)	1.31:1	11.6	30.47 – 40.42	24.96 – 41.61	22.42 – 34.82
3	G3 (30 Teeth)	1.57:1	13.2	26.24 – 35.66	21.96 – 34.33	19.61 – 30.90
4	G4 (37 Teeth)	1.94:1	14.1	21.55 – 26.40	18.12 – 25.29	17.27 – 25.87

Field Test

According to the requirement of the seed for direct seeding purpose, the inclined plate metering mechanisms was selected at 50° and 60° of inclination angle and 4.5 km/h forward speed and tested on inclined plate planter for R1(Rajeshwari) varieties of paddy in three different field at IGKV field for its seeding performance. The emergence was better in case of inclined plate of paddy seeds in all treatments compared to conventional seed-drill in Table 5. Plant to plant spacing, no. of plant/m^2, missing index% and multiple index % of the field are given in Table.6.

Details of the performance of tractor operated inclined plate planter are given in Table 4.

Table 4: Performance of tractor operated inclined plate planter

S. N.	Operational parameters	Tractor operated Inclined plate planter		
		Field 1	Field 2	Field 3
1	Area of the field, m^2	37 × 58 m^2	40 × 60 m^2	100 × 38 m^2
2	Seed rate, kg/ha	25	30	40
3	Variety used	IGKV R1	IGKV R1	IGKV R1
4	Inclination of plate	60°	50°	60°
5	Types of gear used	G4(37 teeth)	G3 (30 teeth)	G4 (37 teeth)
6	Types of metering plate used	M Type	M Type	L Type
7	Plant / m^2	57	58	71
8	Plant to plant spacing, cm	12.2	10.8	8.0
9	Row to row spacing, cm	22.5	22.5	22.5
10	Time req. (h/ha)	0.58	0.55	0.75
11	Speed (km/h)	4.39	4.55	4.45
12	TFC (ha/h)	0.88	0.91	0.89
13	EFC (ha/h)	0.74	0.77	0.76
14	η (%)	84.09	84.61	85.39

Table 5: Comparison of different method of planting of paddy

Operational parameters	Inclined plate planter	Conventional seed-drill
EFC (ha/h)	0.77	0.68
Time req. (h/ha)	1.29	1.47
Man-days required/ha	2	2
Cost (Rs/ha)	803.42	915.53

Table 6: Field observation of inclined plate planter

No. of Field	Seed rate in kg/ha		Spacing, cm (plant to plant)	No. of plant/m²	Missing hill	Missing index %	No. of Multiple hill	Multiple index %
1	25	Mean	12.2	61	1.66	5.20	2.66	8.33
		SD	0.4	2.64	0.57	1.80	1.15	3.60
		CV%	3.27	4.37	34.6	34.641	43.30	43.30
2	30	Mean	10.8	67.33	1.66	4.16	3.66	9.16
		SD	0.36	5.03	1.15	2.88	0.57	1.44
		CV%	3.33	7.47	69.28	69.28	15.74	15.74
3	40	Mean	8.03	74.66	2	4.16	3.33	6.94
		SD	0.47	2.30	1	2.08	0.57	1.20
		CV%	5.88	3.09	50	50	17.32	17.32

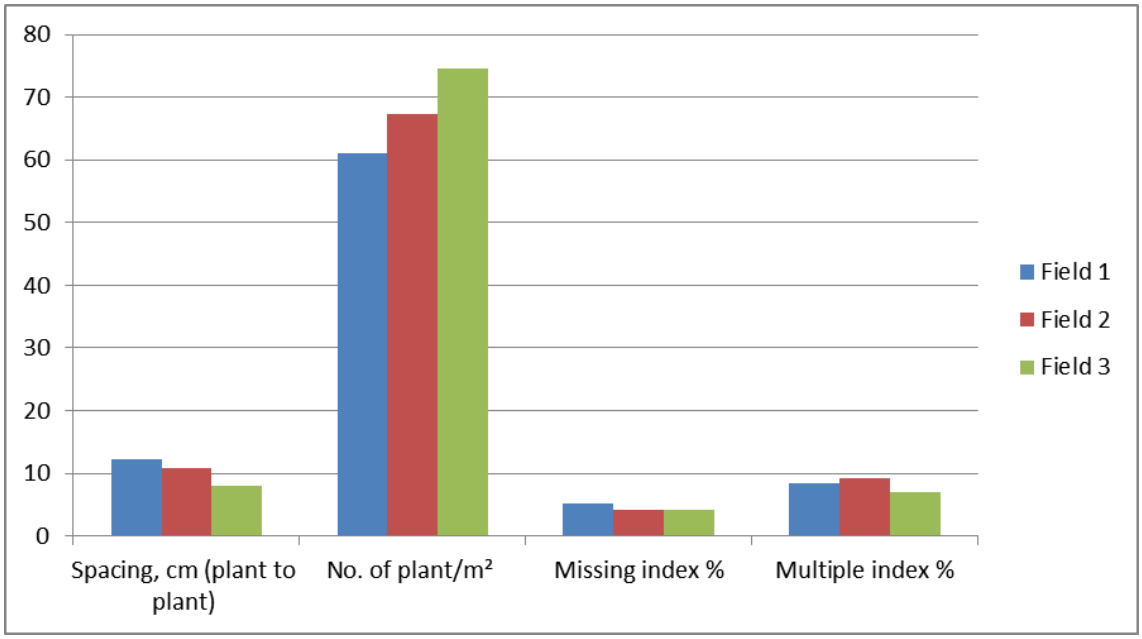


Fig 4: Plant to plant spacing, no. of plant/m^2, missing index% and multiple index % of the field 1, 2 and 3

Optimization of seed rate for all thirteen varieties of paddy

On the basis of calibration and field performance of a inclined plate planter optimum the seed rate for all thirteen varieties of paddy. Details are given in Table 7.

Table 7: Optimum seed rate for all thirteen varieties of paddy.

S. No.	Varieties of paddy	Seed rate in kg/ha	
		Angle of inclination of metering plate 60°	
		Types of gear	
		G3 (30 teeth)	G4 (37 teeth)
01	Mahamaya (V1)		21.70
02	IR 36 (V2)		21.63
03	Purnima (V3)	22.86	
04	Danteshwari (V4)		21.07
05	Karmamasuri (V5)	21.96	
06	Bamleshwari (V6)		19.70
07	Chandrahashini (V7)		21.44
08	Swarna (V8)		20.06
09	Maheshwari (V9)		23.95
10	IGKV R1 (V10)		21.33
11	Jvaful (V11)		18.17
12	Indira Barani (V12)		25.29*
13	HMT (V13)	22.85	

Conclusion

The metering device was tested in all three inclination angle and four gear ratio viz. 50°, 60°, 70° and 1: 1, 1.31:1, 1.57:1 and 1.94:1 respectively. The results of lab test shows that the seed rate increase with decreasing the angle of inclination of metering plate and also increasing with decreasing gear ratio for all thirteen varieties of paddy. The seed spacing varies with the different gear ratio of inclined plate planter. Seed spacing is increases with increasing in gear ratio. Seed spacing was found in the field test at gear G3 (30 teeth), G4 (37 teeth) and G5 (45 teeth) are 8 cm, 10 cm, and 12 cm respectively for all varieties of paddy. With the help of calibration and field performance of a inclined plate planter optimum seed rate at 60^o inclination angle of metering plate in

gear 4 are range from 18- 25 kg/ha. Therefore, at the circumstances of agricultural labor shortage adoption of mechanical planting would be a viable technological option for raising lentil production at the field level.

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