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Development and performance evaluation of tractor drawn groundnut planter for *Rabi* season

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ABSTRACT : An eight row tractor drawn planter was developed for sowing of groundnut seed in irrigated (*Rabi*) condition at Agricultural Research Station, Anantapur. The seed metering in the planter is of inclined plate type. Power is transmitted from ground wheel to metering system through chain and sprockets. A double point shovel type furrow opener was provided for opening the furrows. The seed is placed in the furrows at desired depth. The implement can be operated by a 35 hp tractor. During evaluation the field capacity of the planter was found to be 0.35 ha/h at the average speed of operation of 2.88 km/h with field efficiency of 66.5 per cent. It was found that, the cost of sowing with local manual seed drill was observed to be 51 per cent higher than the sowing with groundnut planter. Manual seed drill required 11.3 man-h/ha more than the groundnut planter.

KEY WORDS : Groundnut, Seed drill, Planter, Seed rate, Seed to seed spacing, Man-h/ha

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Groundnut (*Arachis hypogea* L.) is an important source of edible oil in India and ranks second in the world (after China) in groundnut production and cultivated in an area of 5.8 million ha with a productivity of 948 kg/ha. Three southern states namely Andhra Pradesh, Tamil Nadu, Karnataka and the Western state of Gujarat together account for close to 80 per cent of the annual output in India. In Andhra Pradesh, groundnut is sown normally from June to July in *Kharif* (rainfed) and November to December in *Rabi* (irrigated). In *Kharif* under rainfed conditions, the area normally stands at around 14.5 lakh ha. About 2 lakh ha of area is sown under *Rabi*.

In Andhra Pradesh, traditionally groundnut is sown directly by hand dropping of seed using funnel and tube attached to 8-row tractor drawn cultivator in both parallel and perpendicular directions under irrigated condition. Main disadvantages with this one are more seed rate and non-uniformity of seed to seed distance in a row. Studies in some countries have shown that seed-cum-fertilizer drills introduced in irrigated areas during the last two decades have increased yields by 10-12 per cent over conventional methods of seeding due to better plant establishment and proper application of inputs (Choudhary, 1983). The interest in the popularizing seed-cum-fertilizer drills is the consequence of non-availability of skilled labour during the sowing season and for judicious utilization of seed and fertilizer due to their increasing costs and at the same time to increase the production of food grains, pulses and oilseeds (Bolton and Booster, 1981). When groundnut is cultivated under irrigated conditions or during post rainy season (*Rabi*) or in summer only bunch types are grown. Under such situation, 140 to 150 kg/ha of seed rate was recommended to maintain plant population of 44 no. per m^2 (ICRISAT-Groundnut Cropping Systems). Keeping this in view, a tractor drawn groundnut planter suitable for *Rabi* season was developed and evaluated its performance.

METHODOLOGY

A 8 row tractor drawn groundnut planter having row to row spacing of 22.5 cm suitable for *Rabi* season was developed in Agricultural Engineering Division, Agricultural Research Station, ANGRAU, Anantapur. The major components are mainframe with hitching unit, hopper, metering unit, seed tube cum furrow opener, ground wheel and power transmitting unit. The detailed specifications of the functional components of groundnut planter is presented in Table A.

Table A : Constructional specifications of functional components of tractor drawn 8 row groundnut planter having row to row spacing of 22.5 cm for *Rabi* season

Component	Specifications	
Main frame	Length	2250 mm
	Width	1150 mm
	Height	600 mm
	Material of construction	MS-U,L and flat sections
Hopper	Number	8
	Volumetric capacity	3165 cm^3
	Slope of hopper wall	62^o
	Shape	Semi-circular
	Overall dimensions (length X width X height)	270 X 238 X 295 mm
	Material of construction	MS sheet (2 mm)
Metering unit	Type	Inclined plate
	Diameter of cell plate	150 mm
	No. of cells	15
	Cell size	10 X 9 mm
	Material	Plastic
Seed tube	Diameter	31.75 mm
	Material	Plastic
Furrow opener	Type	Double point shovel type
		300 X 35 X 5 mm
	Material	MS flat
Ground wheel	Diameter	338 mm
	No. of spokes/lugs	12
	Material	MS flat (50 X 10 mm)
	Lug length	75 mm
Furrow covering device	Dimensions (length x width x thickness)	1965 x 75x10 mm
	Material of construction	MS flat

Main frame with hitching unit :

The main frame was made from 5 mm thick mild steel U-channel section of 40 x 72 mm dimensions. The main frame had 12.7 mm diameter holes at every 10 mm interval throughout its length to facilitate the fixing of all other components. A three point hitching unit was fabricated. It was made up of mild steel flat having dimensions of 50 X 10 mm. The hitching pins 150 mm length were fabricated from mild steel rod of 25.4 mm diameter. The hitching unit was fixed rigidly to the main frame by nuts and bolts.

Hopper :

The groundnut planter consisted of eight hoppers each of 3165 cm^3 volumetric capacity. The hoppers were made of 2 mm thick mild steel sheet. It was fabricated taking into consideration the volumetric capacity required, angle of repose and bulk density groundnut seed. The length of hopper was 290 mm with the diameter of curvature 210 mm. The cross section was kept semi-circular. A sliding plate was provided to maintain the depth of seed layer in pickup chamber irrespective of the filling of main chamber. The slope of the hopper was kept as 62^0.

Metering unit :

An inclined plate type metering unit was designed and developed for groundnut seed. It consisted of a seed plate and picking chamber. The seed plate made of plastic was mounted over a set of bevel gear. It had 15 cells around its periphery. The cells were L-shaped having length 9 mm and height and width each 10 and 8 mm, respectively. The seed plate was mounted at an angle of 60^0 with horizontal so that the extra seed dragged along were dropped before reaching the seed outlet of the picking chamber.

Seed-tube cum-furrow opener :

Eight seed tubes of each diameter 31.75 mm made of plastic were used for passing of seed from metering device to furrow. A double point shovel type furrow opener was selected by taking into consideration the local soil condition (sandy clay loam).

Ground wheel :

The ground wheel is required to drive the metering system and it was designed by taking into consideration the recommended seed spacing of 10 cm in a row for groundnut. The ground wheel was made of 50 X 10 mm mild steel flat. The diameter of the ground wheel was 338 mm and lugs of 75 mm length were provided on the outside of the wheel rim for better traction. The lugs were also made with 50 X 10 mm mild steel flat.

Power transmitting unit :

Transmission system was developed for proper power transmission from ground drive wheel to main shaft of seed metering device through a set of chain and sprocket arrangement. The power transmission consisted of three mild steel sprockets of 17 teeth, eight bevel gears of 17 teeth and eight bevel gears of 24 teeth. Two chains of 12 mm pitch were used for power transfer from drive sprocket of ground wheel to seed metering shaft. The speed ratio of 1.41:1 was provided between the ground wheel and seed plate to get the recommended seed spacing in row.

The planter was evaluated in the laboratory and in the field for its performance. In the laboratory calibration row-to-row variation in seed metering and uniformity in seed delivery over sand bed were evaluated (IS: 6316-1971).

Laboratory calibration :

Row to row variation in seed metering :

Groundnut seed of variety Kadiri-6 was filled in 8 seed hoppers. The ground wheel was jacked up and 25 revolutions were given to the ground wheel. The seed discharged from each of the seed tube were collected separately and weighed. Ten replications were done. Series of tests at full, three-fourth and one half capacity of the hopper were conducted and changes in the seed rates were observed.

Uniformity of seed delivery :

The uniformity of seed delivery within the rows was determined using the sand-bed test. A sand bed was prepared with fine sand and spread uniformly over a leveled surface. The covering blade was removed and the planter was pulled over the sand bed. The number of seed dropped for 3 m length and seed to seed distance was noted for each row. Ten replications were done.

Field evaluation :

The field experiments for the performance evaluation of the tractor drawn groundnut planter were conducted in the experimental farm of Agricultural Engineering Division, Agricultural Research Station, ANGRAU, Anantapur. The field was prepared into fine tilth by twice with spring tyne cultivator followed by leveling for the operation of sowing. The test plot was subdivided into three plots of size 20 m x 30 m. All hoppers were filled with groundnut seed and operated in straight rows. The operation was replicated in three plots. The performance was compared with local seed drill for groundnut seed. A separate test plot was used for local practice of groundnut sowing and field condition was kept similar as per the requirement. The following observations were taken to evaluate the performance of planter.

–Time taken to cover the area
–Actual depth of placement of seed
–Speed of operation
–Man-h/ha for sowing
–Seed rate
–Draft required to operate the planter

The following indicators of performance were calculated using the observed data in the field

Draft :

By double tractor method the draft was recorded by spring type digital dynamometer.

Field capacity :

The theoretical field capacity is the rate of field coverage that would be obtained if the planter was operated continuously without any interruptions like turning at the ends and filling of hopper. The effective field capacity is the actual average rate of coverage including the time lost in filling hopper and turning at the end of rows.

The theoretical field capacity was determined by using the following relationship:

$$\mathbf{TFC = WS/10}$$

where,

TFC = Theoretical field capacity, ha/h
W = Width of operation, m
S = Speed of operation, km/h

$$\textbf{Effective field capacity, } \frac{\textbf{ha}}{\textbf{h}} = \frac{\textbf{Total area covered, ha}}{\textbf{Total time taken, h}} \textbf{x100}$$

Field efficiency :

Field efficiency is the ratio of effective field capacity and theoretical field capacity as shown below

$$\textbf{Feild efficiency} = \frac{\textbf{Effective field capacity, ha/h}}{\textbf{Theoretical field capacity, ha/h}} \textbf{x100}$$

Field machine index :

It indicates the influence of field geometry on working capacity of a machine. Field machine index was worked out by the following formula (Renoll, 1970) :

$$\textbf{FMI, \%} = \frac{\textbf{Tp}}{\textbf{Tp} + \textbf{Tt}} \textbf{x100}$$

where,

FMI = Field machine index
Tp = Total productive time, s
Tt = Turning time loss, s

Cost economics :

The total cost of sowing for both the methods was determined based on the fixed cost and variable cost (IS: 1964-1979). The following variables were considered in determining the cost of operation of the planter.

Fixed cost :

– Depreciation
– Interest
– Insurance and taxes :
– Shelter

Variable cost :

– Repair and maintenance

The total cost of operation was determined as the sum of the fixed and variable cost. The total cost of operation per hour of the machine was computed. The cost of operation of the tractor was also calculated following the same procedure. The cost of fuel, lubrication and operator was added to the variable cost. The total cost of operation was determined by adding the hourly cost of operation of the machine and tractor and expressed in Rupees per hour. It was converted into area basis by multiplying it with the effective field capacity of the machine and expressed in Rupees per hectare.

RESULTS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in following heads:

Laboratory calibration :

In the laboratory the row-to-row variation in seed metering and uniformity of seed delivery were studied. The tests were conducted with full, ¾ and ½ filled hopper. The results indicated that variation of seed discharged from the average of eight rows was less than standard limit.

An overall average of 89.5 g of seed was delivered in 25 revolutions of the ground wheel (Table 1). The maximum deviation of seed discharge of any row from the average was observed to be less than 5 per cent. All the deviations were within the range of 7 per cent set by the Indian standards. No difference in metering was observed with different hopper capacity. This was due to the partition of hopper by sliding plate. The depth of seed layer was same for all the hopper capacity in the pickup chamber, hence no difference was observed for different hopper capacity.

Sand-bed test :

The seeding uniformity was also evaluated by using the sand-bed test. An average of 11.0 seeds were placed per meter length. The maximum deviation of seed of any of the rows from the average was less than 7 per cent set by Indian

Table 1 : Seed distribution in a row with different hopper capacities

Hopper capacity	Average weight of seed discharged in 25 revolutions of ground wheel, g								
	R 1	R 2	R 3	R 4	R 5	R 6	R 7	R 8	Average
Half hopper									
Average	91.68	92.1	89.5	87.82	86.49	90.6	90.24	87.58	89.5
Maximum deviation from average	2.44	2.9	0	1.88	3.36	1.23	0.82	2.17	
Three-fourth hopper									
Average	86.15	83.72	91.8	92.1	90.76	85.2	87.8	87.06	88.0
Maximum deviation from average	2.1	4.86	4.32	4.66	3.14	3.18	0.22	1.07	
Full hopper									
Average	90.61	89.96	92.0	89.35	86.9	91.72	92.15	89.74	90.3
Maximum deviation from average	0.34	0.37	1.88	1.05	3.77	1.57	2.05	0.62	

Table 2 : Sand bed test for seeding uniformity

Parameter	Number of seed per meter length of bed								
	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	Average
Mean	10.26	11.3	11.0	10.93	10.6	10.8	11.4	11.72	11.0
Maximum deviation from average, %	6.72	2.72	0	0.64	3.63	1.82	3.64	6.55	
Parameter	Seed to seed spacing obtained, cm								
	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	Average
Mean	10.2	9.8	10.0	9.7	10.6	9.5	11	10.0	10.1
Maximum deviation from average, %	0.1	2.97	0.1	3.96	4.95	5.94	8.91	0.1	

R - row

Table 3: Field performance data of *Rabi* groundnut planter

Performance parameters	Values
Average draft, kgf	482
Average speed, km/h	2.88
Average depth of placement, cm	4.7
Average field capacity, ha/h	0.35
Average field efficiency, %	66.5
Field machine index, %	82
Labour requirement, man-h/ha	5.6
Seed rate, kg/ha	147
Plant population per m^2 at 15 DAS	43

Note: Soil moisture content = 18%, Soil bulk density = 1.12 g/cc

standards. Average seed to seed spacing observed was 10.1 cm and this was almost equal to recommended seed to seed spacing for groundnut *i.e.* 10 cm. Hence, it could be concluded that the prototype planter performed satisfactorily in metering groundnut seeds (Table 2).

Field performance test :

Field performance tests were carried out to obtain actual data on overall performance of the groundnut planter in comparison to traditional practice. The field tests were done in the experimental farm of Agricultural Engineering division. The performance data of the planter are presented in Table 3.

The average draft requirement of 482 kgf was recorded for the groundnut planter. Hence, a medium size tractor (35hp) could easily operate the planter. An average field capacity of 0.35 ha/h was obtained for continues operation of groundnut planter at an average speed of 2.88 km/h. A field efficiency of 66.5 per cent was observed which was in the prescribed range of 65 – 75 per cent for row crop planter (Kepner *et al*., 1987). The major loss in field efficiency was due to the turns at headland and adjustment of planter position before run so that the ridges formed in the previous pass were not disturbed. No break down, repairs and adjustment of components during the observation was observed. The average depth of placement of seed of ten observations randomly selected was 4.7 cm. The field machine index was recorded at an average of 82 per cent. This was due to the rectangular size of the test plot and less turning time at the head land. The average seed rate observed in the field was 147 kg/ha as against the recommended value of 140 to 150 kg/ha. The average number of plants per m^2 at 15 days of sowing was 43 and it was nearer to recommended plant population of 44 per m^2

The cost of the prototype planter was worked out to be Rs.55,000/- and hourly cost of operation was computed to be Rs.468. The man-h requirement for planting one hectare of land was observed to be 5.6. The cost of planting by planter was Rs.1317/- per hectare as against Rs.1991/- per hectare for local tractor drawn seed drill for sowing of groundnut seed. The cost of sowing with local manual seed drill was observed to be 51 per cent higher than the groundnut planter and required 11.3 man-h/ha more than the groundnut planter.

Conclusion :

The planter has a field capacity of 0.35 ha/h and it can be operated by a 35 hp tractor. The saving in man-hours requirement and in terms of cost of planting was quite substantial and justified the use of planter.

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