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Comparative Field Assessment of Sowing of ragi by Seed Cum Fertilizer Drill and Broadcasting Techniques

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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

One of the primary challenges in ragi cultivation is the reliance on traditional farming methods, which involve labor-intensive practices from land preparation to post-harvest operations. This not only increases production costs but also contributes to excessive drudgery. Labor shortages,

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especially during peak farming periods, further exacerbate the situation by driving up costs and reducing overall productivity. In this context, mechanization has become critical for ensuring timely agricultural operations, which are key to maximizing crop yields. The evaluation of tractor-operated seed drills has shown promising results, including a reduction in seed usage when compared to traditional methods. It is found that the effective field capacity and field efficiency is 0.77 ha/h and 92.7 per cent respectively. Cost of savings when compared to the broad casting is Rs. 239/ha. Moreover, the mechanization of ragi sowing has effectively eliminated the drudgery associated with manual sowing, making the process more efficient and cost-effective.

Keywords: Tractor operated; seed drills; mechanization; line sowing; broad casting.

1. INTRODUCTION

In 2023, India cultivated finger millet on approximately 1.1 million hectares, producing around 1.8 to 2.0 million metric tons, with Karnataka being the largest producer, accounting for nearly 60% of the country's output. Africa, particularly Uganda, Kenya, and Ethiopia, is also a significant producer. Global production is estimated at 4 to 5 million metric tons annually.

"In Tamil Nadu, finger millet, known locally as "Kezhvaragu" (கேழ்வரகு), holds cultural and nutritional significance, being a traditional crop cultivated for generations. It thrives particularly well in the dry and semi-arid regions of the state due to its ability to withstand drought and poor soil conditions. Finger millet is especially grown in districts like Dharmapuri, Krishnagiri, Salem, Madurai, Tiruvannamalai, and Vellore, where it serves as both a staple food and a source of income for small-scale farmers" [1].

Tamil Nadu's cultivation practices emphasize organic and traditional methods, though recent years have seen efforts to improve yields through better seed varieties and sustainable farming practices. The crop is planted during the Kharif season, relying on monsoon rains for irrigation. On average, finger millet occupies around 82919 hectares in Tamil Nadu, producing a moderate yield of approximately 288627 tons per hectare (Statistical Hand Book of Tamil Nadu-2020-21).

"Alternatively, the reduction in input resources is a great challenge for realizing the goal of green development in agriculture and sustainable grain production in the future [2]. Scaling of agricultural mechanization and the comparative impact is a great initiative to support small landholders" [3,4].

"Sowing of seeds with seed drill at proper seed rate, depth and covering them with soil is very important. This allows plants to get sufficient sunlight and nutrients from the soil and also saves them from being eaten by birds or being dried up due to exposure to sun. Meanwhile it ensures improved ratio of crop yield with saving in time and labour" [5]. "Manual sowing is time consuming requires about 20 to 30 man-hours per ha of land, and that takes away about 8per cent of total manhours in farming and costly. Hence, there is a need for appropriate seed drill for sowing" [6].

Chaudhuri, 2001 evaluated "the performance of furrow openers, which show in general that an increase in the rake and horizontal included angles increases furrow depth and furrow area. For light sandy soils, a rake angle of 130° was found to be best for the depth stability of the openers. Quadratic relationships were found for depth force relationships for both horizontal and vertical forces, whereas the force–rake angle relationship was found to be both speed and width dependent".

"Finger seeds are generally sown under rainfed condition by broadcasting without any land preparation and ploughing is done subsequently to cover the seeds but with advances in management techniques seeds are sown in rows as line sowing at 22.5-30 cm apart manually. Manual sowing has the problem of labour availability as rain is uncertain and labour availability at that time is troublesome and there is also uncertainty in depth of sowing as per the situation. The timeliness of operations has assumed greater significant in obtaining optimal yields from different crops, which has been possible by way of mechanization" [7]. But in sowing particularly in rainfed sowing, sowing depth is important to avail the soil moisture at the maximum for better seed emergence. In comparison to conventional farming by using improved set of equipment labour dependency and cost of cultivation was reduced [8].

Mechanical sowing using seed drill is the best alternative for rainfed sowing with the option of

proper placement in correct depth at the earliest as possible after the receipt of rains. Khobragade et al., [9], in his study reported that, "tractor operated seedcum-fertilizer drill works better than bullock drawn seed drill in respect of effective field capacity, field efficiency, depth of placement of seed, yield of crop, yield of fodder and cost of sowing per hectare in sorghum cultivation". "The crops were also sown with the conventional method of sowing on flat surface using a tractor-drawn device fitted with a tine-type cultivator coupled with manual seed metering and mounted with a planker to cover the seed" [10]. "With plots sown by the conventional method, the recommended dose of fertiliser was broadcast after the emergence of the seed. Finger millet sowing using tractor drawn seed drill coupled with cycle weeding and harvested mechanically found more remunerative by saving time, labour and reducing drudgery for the farmers" [11]. Hence studies were conducted to evaluate the cost-effective mechanization in finger millet on sowing with machinery like tractor operated seed drill.

2. MATERIALS AND METHODS

The existing tractor operated seed cum fertilizer drill which is mostly used for sowing groundnut and maize in these north western regions is selected for this study to sow the ragi seeds. Before sowing of seeds using the existing tractor operated seed cum fertilizer drill, it has to be calibrated properly to ensure the precise metering of seeds from the hopper to the furrow opener. The existing tractor operated seed cum fertilizer drill metering rotor number 3 is used to the big seeds which has 11 furrow openers and operational width of 3.0 m. The seed cum fertilizer drill is provided with 7 types of rotors by the manufacturer for metering the various seeds like maize, sunflower, groundnut, ragi, mustard etc.. For sowing of ragi seeds, rotor number 13 (As recommended by the manufacturer for mustard /pearl millet crops) was replaced to the seed metering shaft instead of rotor number 3 in the seed drill. In total 11 seed metering rotors fixed to the seed metering shaft to the seed drill for metering the ragi seeds from the hopper.

2.1 About Rotor Number 13 in Seed Drill

The rotor part is usually made of durable plastic material chosen for its precision molding capabilities, resistance to wear, and ability to handle various seed types without causing damage. It is plastic moulded rotor which is used to carry the small seeds like ragi, mustard, pear millet etc. and drop the same in the funnel where it reaches the furrow continuously.

2.2 Calibration of Tractor Operated Seed Cum Fertilizer Drill for Sowing ragi

Laboratory test was conducted with rotor number 13 to find the number of ragi seeds taken by the rotors of the seed drill. The rotor used to carry 4 to 5 number of ragi seeds seeds. Hence, calibration of the existing seed drill was done by operating the cup feed seed drill on plain ground surface covered with a plastic sheet to collect the ragi seeds metered by the machine. The ragi seed variety Paiyur 2, the current ruling variety is taken and required quantity is filled in the respective hopper of the seed cum fertilizer drill. The seed drill was operated by lifting the implement so that the furrow opener was slightly above the ground. The ground wheel was lowered to transmit the drive to metering mechanism. The quantity of ragi seeds per rotor was recorded based on the unit length of forward travel. The details of calibration of seed drill was as follows:

List 1. The procedure of calibration of seed drill

Circumference of ground wheel (π D)	:	3.14 x 40 = 125.6 cm = 1.26 m
Width of seed drill (Number of furrow opener x width of seed drill)	:	11 x 0.30 m = 3.3 m
Area covered for one revolution (Circumference of ground wheel x Width of seed drill)	:	1.26 m x 3.3 m = 4.16 m^2
Number of turns needed/ha	:	10000 m^2 / 4.16 m^2 = 2404 turns
Number of grains taken by the cup	:	5 seeds 5 seeds / cup x 8 cup holes / revolution 40 seeds x 11 rows 440
Therefore for 2404 tunes, the number of grains to be dropped.	:	440 x 2404 = 1057760 seeds / hectare
	:	1057760 seeds
Calculated 1000 seed weight is 3.47g	:	3670 g
	:	3.67 kg/ha

On calibration of the seed drill, it is observed that each rotor cup picks around 4 to 6 numbers of seeds from the hopper and the same was dropped to the funnel for sowing. Around 3.67 kg ha^{-1} seed was used for sowing in the field with the selected tractor operated seed cum fertilizer seed drill. The actual recommended seed rate for sowing ragi seed is also 10 kg ha^{-1} in adoption of broad casting (Crop Protection Guide, 2020) for sowing the seeds.

2.3 Field Evaluation of Seed Drill Sowing for ragi Seed under Rainfed Condition

The tractor operated seed cum fertilizer drill was evaluated for its performance under field condition in an area of 0.15 ha with the latest ragi var. Paiyur 2 prepared through conventional primary tillage in field No. 3 of F block of Regional Research Station, Paiyur. The furrow opener and the depth control were so adjusted to have a planting depth of 25-50 mm. The tractor was operated at speed of 2.0 to 3.0 kmh^{-1}. The ragi seeds were sown using the seed cum fertilizer drill at row-to-row spacing of 300 mm and plant-to-plant spacing of 100mm (Plates 1 & 2) as rainfed ragi crop. View of the field after sowing operation is shown in plate 3. The observations like seed rate, field capacity, field efficiency and seed germinations were recorded during the operation of tractor operated seed cum fertilizer seed drill [12-14].

2.4 Cost Economics

To access the cost economics, the benefit-cost ratio (BCR) tool is used to evaluate the costs and benefits of a tractor operated seed cum fertilizer drill with the traditional methods of sowing. The comparison of seed rate and cost economics of the tractor operated seed cum fertilizer drill and traditional method of sowing is also reported.

For comparison, seeds were also sown in an area of 5 cents simultaneously adopting broad casting technique. The crop was grown as pure rainfed crop.

Plate 1. Tractor operated seed cum fertilizer seed drill for sowing ragi seeds

Plate 2. Tractor operated seed cum fertilizer seed drill in the actual field

Seed drill sowing

Broad casting

Plate 3. View of the field after sowing operation

3. RESULTS AND DISCUSSION

3.1 Field Evaluation

On evaluation of the performance of the cup feed seed drill, initially for the field parameters viz., the field capacity, field efficiency, seed rate and seed germination as follows:

Theoretical field capacity (C):

It was calculated by using the below formula:

$$C = \frac{S \times W}{10}$$

Where,

C= Theoretical field capacity; ha.hr^{-1}
S= Forward speed, km.hr^{-1}
W=width, m
C = 2.5× (0.30×11) /10
= 0.83 ha.hr^{-1}

3.2 Effective Field Capacity, EFC

The effective field capacity of will include time lost during the actual field operation such as time lost due to turning, loading, adjustment and other time losses during the operation.

$$EFC = \frac{A}{T}$$

Where:

EFC=Effective field capacity**,** ha.hr^{-1}
A=area, hectare
T=time to finish the area, hr
= 0.164/0.213
= 0.77 ha.hr^{-1}

3.3 Field Efficiency (FE) (%)

The field efficiency was calculated by using the below expression:

$$FE = \frac{EFC}{C} X\ 100$$

Where,

EFC=Effective field capacity**,** ha.hr^{-1}
C= Theoretical field capacity; ha.hr^{-1}
FE = (0.77/0.83) ×100
= 92.7 %

3.4 Seed Rate (SR), kg/ha

For measuring the seed rate, known quantity of ragi seeds (Initial weight) were dropped in the seed hopper before starting the operation. After completing the sowing operation, the left-over seeds in the hopper are removed and weighed (Final weight) in the electronic weighing balance to obtain the sown weight of the ragi seeds. The seed rate was measured using the below expression:

$$SR = \frac{W}{A}$$

Where,

W = Weight of sown seeds, kg
A= Area, ha
Sr = 0.637/0.164
= 3.88 kg/ha

It is found that the sowing with tractor operated seed cum fertilizer seed drill delivers 3.88 kg/ha when compared to broad casting (Recommended seed rate @ 10 kg/ha). From

the results, it is found that there is reduction in seed rate by 61.2 per cent when compared to the broad casting:

3.5 Seed Emergence (%)

As per the data on eleven sowing approximately 100 seeds would be sown. Based on that in thirteen different places the number of seeds emerged were counted and using the following formula the seed emergence was calculated in percentage. Similarly, by broadcasting 100 seeds in 13 different places were broadcasted and the mean was calculated in percentage and the data were statistically analyzed for significance.

$$\text{Seed Emergence (\%)} = \frac{\text{Number of seeds germinated}}{\text{Number os seeds sown}} \text{ x } 100$$

The results of the above parameters were as follows (Table 1).

3.6 Measurement of Depth of Placement of Seeds

Depth of seed placement was measured by removing the plant from soil, and measuring the depth at which the seed was placed. Plot size of one square meter was randomly selected from the field and measured the depth of sowing by removing the plant from soil in five different places. The values of depth of sowing of the seed drill were recorded and the mean reported in mm (Table 2). The results indicated the average sowing depth in seed drill as 52±0.20 mm.

3.7 Cost Economics

The cost economics of using the Tractor operated seed cum fertilizer drill was calculated and reported.

From the table, it is found that, due to capital cost of the tractor, the hiring charges are more when compare to the broad casting. It is also found that seed rate is less (3.88 kg/ha) when using the tractor operated seed cum fertilizer drill. Due to decrease in seed cost, there is an 14.9 % reduction per hectare in the sowing cost when compared to the broad casting. From the evaluation, two human labours are required to broadcasting the ragi seeds for 7 hectares per day of 8 hours where as in machine sowing 4.5 ha per day of 8 hours. From the results, it is found that labour requirement is reduced to 50 per cent and also the area coverage is more when compared to broad casting.

Table 1. Field and machine characters on mechanical sowing

Field and machine parameters	Values
Theoretical field capacity, C	0.83 ha.hr^{-1}
Effective field capacity, EFC	0.77 ha.hr^{-1}
Field Efficiency (FE)	92.7 per cent
Seed Rate, SR	3.88 kg/ha
Seed emergence (%)	87 per cent

Table 2. Measured values of Depth of placement

Particulars	Depth (mm)
Depth of sowing (mm)	52
S.E	0.10
95% confidence limit	52± 0.20

Table 3. Comparison of sowing cost with seed drill and broad casting methods

Type of operation	Traditional Method (Broad casting), Rs/ha	Seed drill sowing Rs./ha
Seeds rate, Rs 100/kg	Rs. 1000 /ha @ 10 kg	Rs.388/ha @ 3.88 kg
Cost of hiring of tractor and seed drill	-	Rs.973 /ha
Cost of hiring of skilled labor for broad casting	Rs.600	-
Total cost involved, Rs.	**1600**	**Rs.1361**

4. SUMMARY AND CONCLUSION

The performance of the tractor operated seed cum fertilizer drill evaluated under rainfed condition revealed that, the effective field capacity was found to be 0.77 ha/h with 92.7 per cent field efficiency. The average sowing depth in seed drill is 52 ±0.20. while using the tractor operated seed cum fertilizer drill. From the results, it is found that, the cost of operation of cup feed seed drill along with tractor is Rs.973/ha and the cost savings in using the tractor operated seed cum fertilizer dill is Rs. 239/ha. Labour requirement for sowing the ragi seeds using the

seed drill is reduced by 50 per cent and also the area coverage is more when compared to broad casting methods

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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