Original Research Article

Development of power operated portable sesame thresher for small farmers

ABSTRACT

Threshing of sesame seeds from the harvested capsules is one of the important operations and it consumes more labor, time and cost. Hence the development of a power operated portable sesame thresher is timely essential for the small farmers. The physical properties of sesame seeds namely size of the seed, Number of seeds per capsule, 1000 grain weight and length and thickness of capsules were studied for developing a power operated portable sesame thresher. The most popular variety used in Tamil Nadu is *TMV 7*. The average length and thickness of capsules were measured as 35 and 12 mm respectively. The average number of seeds in single capsule was determined as 60. The average 1000 grain weight was determined as 3.1 g. and the average size of the seed is 3×1.8× 0.9 mm. Based on these results the portable sesame thresher was fabricated based on double roller (two rollers are rotating with opposite direction) mechanism with an overall size of 1392 ×700 ×1170 mm and its performance was assessed in terms of threshing efficiency, output capacity, saving in cost and time and compared with conventional methods of manual threshing. The developed portable power sesame thresher was field tested and its threshing efficiency and seed output capacity were 96.7 % and 18.2 kg h^{-1}, respectively. The saving in cost and time were 92 and 72 % respectively as compared to conventional method of manual threshing.

Key words: *Sesame, Thresher, Two Roller, Threshing efficiency, Output capacity.*

1. INTRODUCTION

In India sesame is largely produced for its oil and is also used as a flavoring agent. The seeds have high oil content around 55%. India's annual average production hover around 6, 80,000 metric tonne contributing to around 22% of the world's total sesame production. According to Ministry of Agriculture, in Tamil Nadu, sesame was cultivated in 0.66 lakh hectares with a production and yield of 0.36 lakh tonnes and 596 kg/ha respectively during 2014-15. About 65 % of the annual sesame crop is processed into oil and 35 % is used as food. The crop is cultivated twice a year, during December - January and July - August. Threshing is the detachment of the sesame seeds from the capsule of the sesame plant. Threshing is recognized to be a very labor intensive operation and involve considerable human drudgery. Manually it can be done by hand beating and manual methods results in high time of operation and high losses than the mechanical method also further, delay in threshing operation, results in delay in sowing of the next crop and hence it reduced the yield. The thresher available requires high horsepower motor or PTO of tractor. Hence during threshing one tractor owned by the farmer is not available for other farm operations such as seedbed preparation. The existing thresher cannot be taken to the interior fields of the farmer where we do not have proper approach roads to the fields. Keeping in view of the problems arising in threshing of sesame, the portable sesame thresher was developed. It can be taken by two persons to any corner of the interior sesame fields. The prime mover is diesel driven 2.2 kW engine.

The physical properties of sesame seeds related to threshing mechanism were studied. According to (Zebib *et al.,* 2015) the average values of 1000 seed weight were ranged from (2.74 - 3.16 g) and true density from (1190.66 to 1215.58 kg m^{-3}). (Darvish, 2012) state that the average length, width and thickness from 3.019 to 3.074 mm, 1.844 to 1.935 mm and 0.724 to 0.771 mm respectively and the angle of repose range from 20.16° to 28.67°. (Yilmaz *et al.,* 2008) stated that a rasp bar with tooth type threshing drum with three speeds of 6.5, 9.1 and 11.7 m/s, three feed rate as 90, 180 and 270 kg/h and three concave open as 20, 35 and 50 mm were used in this study. Results show that the best performance for separation of sesame straw were gave at the maximum drum speeds, minimum feed rates and concave opens. (Hyun, 2014) developed a machine for separating shatter-resistant sesame after threshing. For separation, using a sieve perforation size of 5 mm and blower speed of 220 rpm given an optimum separation and loss ratios, of 96.5% and 3.5%, respectively. (Olugboji, 2004) developed rice thresher has the ability to winnow the premature grains and leaves and calculated the total power required to comb off grains from stalk is 267.04 W and to be driven by a 1.5 hp electric motor.

(Pandey and Stevens, 2016) stated that the maximum threshing efficiency for gram was found to be 98.98 % at cylinder speed of 600 rpm and feed rate 20 q/h. The output capacity was found 9.62 q/h at cylinder

speed of 600 rpm and feed rate 20 q/h. (Lee *et al.,* 2009) measured the shattering ratio by developed machine was 97.2 % and the work hour per area of 10 acre for the mechanical work and the manual work were 0.3 hour and 13.9 hour, respectively. (Tiwari *et al.,* 2018) reported that the small light weight power threshers (0.75 kW) have been developed for hilly region states. The axial flow threshers for sunflower, groundnut, soybean, rice and wheat are commercialized across the country. (Naik *et al.,* 2010) designed a pedal-operated paddy thresher and evaluated for optimal design parameters, viz., wire loop spacing 39.1 mm, wire loop tip height 60.6 mm and threshing drum speed 339.46 m min^{-1}. The corresponding threshing capacity and efficiency were 64.6 kgh^{-1} and 96.4 % respectively.

2. MATERIALS AND METHODS

2.1 Physical properties

The crop parameters influencing mechanical threshing of sesame seeds were identified and determined. The crop properties, relevant to the design of thresher components were identified as the length and thickness of capsule, Number of seeds per capsule, size and shape, thousand seed weight, test weight and angle of repose. The most popular variety among the farms of Tamil Nadu *TMV 7* was used throughout the investigation. Length of capsule: One sesame capsule was selected at random from the harvested heap and its length and thickness was measured with a scale after placing it on a horizontal platform in its natural rest position. This procedure was repeated for nine more capsules of sesame and the observations were recorded. The moisture content of the capsule was determined by *OSAW* moisture meter.

Number of seeds per capsule: Ten number of sesame capsule was selected at random. The seeds in the capsule was separated manually and counted. Size and shape of seed: The size and shape of the seed are important parameters in designing the rollers and sieves. The size and shape of *TMV 7* variety were determined by digital vernier caliper having the accuracy of 0.02 micron. Twenty seeds were selected in random. The sesame seeds have an ellipsoid shape with three main dimensions, the length (longitudinal dimension), the breadth (dorsoventral dimension) and thickness (lateral dimension). Thousand-grain weight: The weight of thousand grains randomly selected from a heap of sesame crop was weighed in an electronic weighing balance having a sensitivity of 0.1g the experiment was replicated ten times and the observation was recorded. Evaluation of existing practices of sesame threshing and comparison: The conventional method of threshing sesame involves drying the crop in the field itself for 6-8 days. After that the crop was harvested and threshed in the field using a stick. The beating action shreds the seeds from the capsules. The threshed seeds are cleaned using manual sieve.

2.2 Development of power operated portable sesame thresher

A power operated sesame thresher was developed with the following components; the main frame was made up of mild steel 'L' angle. It is supporting the different components of thresher such as feed chute, threshing rollers and sieves. An inclined feed chute was fitted at one end of the roller. The shape, slope and size were fabricated as per the IS standards for uniform feeding of crop in to the rollers. The thresher was mounted with a wooden roller and mild steel roller. The roller of 200 mm diameter and 350 mm length supported by a shaft fixed to the main frame of the thresher with the help of bearings. One end of the shaft is fitted with a stepped V- belts and pulley, to throw the threshed materials at the outlet. The primary outlet 616 mm is used to collect the threshed grain and Secondary outlet is to throw the threshed straws. Separation unit consists of three layers of sieve openings (respectively 7mm, 5mm, and 3mm) to separate the sesame seeds from the straws and impurities. It was connected to the shaft of the pulley using cam which gives reciprocating movement to the separation unit. A One hp electric motor or engine is fitted to the threshing unit at an appropriate place. Provision is made at the base point to move the engine to and fro to create a belt tension with the help of V-pulley and belt. The overall dimension of the power operated sesame thresher is 1392 ×700 ×1170 mm (Fig.1).

2.3 Performance evaluation

The thresher with a stationary roller and a moving roller was evaluated to study the threshing performance by crop and operational parameters. The variables affecting the performance of the thresher were the crop moisture content, feed rate, roller speed and clearance between rollers. The analysis was carried out to determine the roller speed and clearance between rollers to get maximum threshing efficiency, output capacity and minimum grain damage. The standard peripheral speed of drive roller 7.5 ms^{-1} should be selected to give maximum threshing efficiency, minimum damage and high output. The thresher was operated for a period of six hours and the performance was evaluated following the test procedure described by *IS: 11234: 1985.*

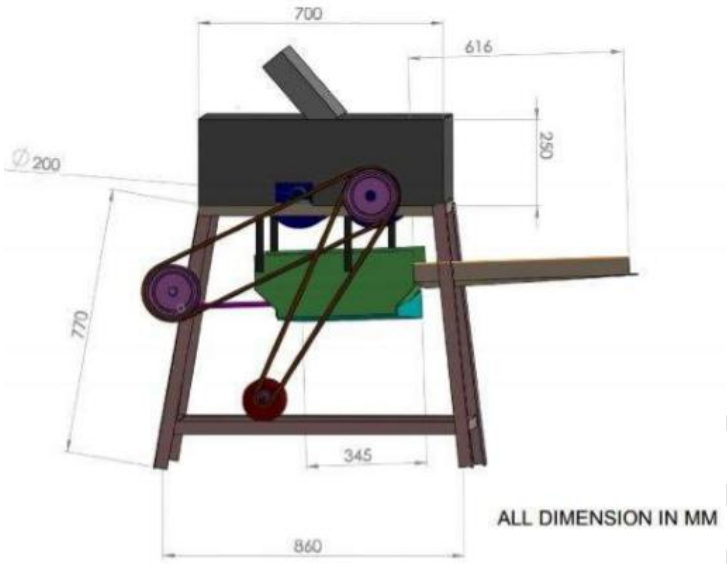

Fig.1. Power operated sesame thresher

Fig.2. Threshing mechanism-Drive (Wood) and driven (Iron) rollers

Fig.3. Power operated portable sesame thresher

Table 1 Levels of Variables for thresher

Threshing cylinder	Feed Rate (R), kg/h	Roller Clearance (C), mm	Moisture content(M),%	Affected response variables
Double roller mechanism Driven (Iron) & Drive roller (Wooden)	140 180 220	5 10	13.5 16 18.5	Threshing efficiency Output capacity

Output capacity: The output capacity was estimated by weighing the total grain received per hour at primary output of the thresher.

Total grain output A = B + C + D

Where, A = Total grain input per unit time by weight

B = Weight of threshed grain per unit time collected at the main grain outlet.

C = Weight of threshed grain per unit time collected at all outlets except from main grain outlet.

D = Weight of unthreshed grain from all outlets per unit time.

Threshing efficiency: The percentage threshing efficiency was estimated using the following equation. (RNAM, 1983)

Threshing efficiency, % = 100 – Percentage of unthreshed grain

Percentage of unthreshed grain = (H / A) 100

Where, H = Weight of unthreshed grain per unit time at all outlets.

2.4 Cost of economics

The total cost of the power operated sesame thresher was arrived and fixed and variable costs for operating the unit per hour was calculated as per the procedure described by *ARE: 9164:1979.* From the field capacity of the unit, the cost of operation per 100 kg of grain was calculated. This cost was compared with conventional method of threshing cost for threshing 100 kg grain. The saving in cost and time using the power operated sesame thresher was arrived.

3. RESULTS AND DISCUSSION

The physical properties of *TMV 7* sesame variety were analyzed. The performance of threshing systems under different sesame moisture content, feed rate, roller speed and clearance between rollers was obtained. Length and thickness of capsules, Number of grains per capsule, size and shape of grains and thousand grain weights.

3.1 Physical properties

The average length and thickness of capsules were measured as 35 mm and 12 mm for *TMV 7* variety. The average number of seeds in single capsule was determined as 60. The average 1000 grain weight was determined as 3.1 g. and the average size of the seed is 3×1.8× 0.9 mm (Table 2).

Table.2 Results of physical properties of sesame

Physical property	Minimum	maximum	Average
Length of capsule, mm	20	40	35
Thickness of capsule, mm	10	15	12
Seed Length, mm	2.8	3.3	3
Seed Breadth, mm	1.6	2.0	1.8
Seed Thickness, mm	0.7	1.2	0.9
Seeds per capsule, Nos.	56	65	60
1000 grain weight, g	2.8	3.6	3.2

3.2 Combined effect of moisture content, roller clearance and feed rate on threshing efficiency

Table 3. Interaction effects of M x C x R factor means on threshing efficiency, %.

Feed rate (R), kg h^{-1}	Moisture content (M), %			F-Mean
	13.5	16	18.5	
C= 5 mm				
140	95.7	95.5	94.5	95.23
180	96.7	95.3	93.5	95.17
220	94.7	93.1	92.0	93.27
C= 10 mm				
140	94.3	92.8	91.0	92.70
180	94.0	93.0	90.7	92.57
220	91.5	90.0	88.2	89.90
S-Mean	94.48	93.28	91.65	93.14

Table 3 showed the combined effect of moisture content, roller clearance and feed rate. It is seen that the increase in moisture content and increase in feed rate at each roller clearance had significant effect on threshing efficiency varying the mean threshing efficiency from 89.90 to 95.90 %. The maximum threshing efficiency of 96.7 % could be achieved at a moisture content of 13.5 % with a feed rate 180 kg h^{-1} and roller clearance 5 mm. The minimum threshing efficiency was 88.20 % moisture content of 18.5 % with a feed rate 220 kg h^{-1} and roller clearance 10 mm.

3.3 Combined effect of Moisture content, Roller clearance and feed rate on Output capacity

Table 4. Interaction effects of M x C x R factor means on Output capacity, Kg h^{-1}.

Feed rate (R), kg h^{-1}	Moisture content (M), %	F-Mean

	13.5	16	18.5	
C= 5 mm				
140	13.2	10.8	9.2	11.07
180	18.2	16.5	15.4	16.70
220	22.8	21.6	19.5	21.30
C= 10 mm				
140	13.8	12.6	11.4	12.60
180	17.7	17.4	17.0	17.37
220	19.8	18.6	17.9	18.77
S-Mean	17.58	16.25	15.07	16.30

Table 4 showed the combined effect of moisture content, roller clearance and feed rate. It is seen that the increase in moisture content and increase in feed rate at each roller clearance had significant effect on output capacity varying the mean output capacity from 11.07 to 18.77 kg h^{-1}. The maximum output capacity of 22.8 kg h^{-1} could be achieved at a moisture content of 13.5 % with a feed rate 220 kg h^{-1} and roller clearance 5 mm. The minimum output capacity was 9.2 kg h^{-1} moisture content of 18.5 % with a feed rate 140 kg h^{-1} and roller clearance 5 mm. The effect of all the individual factors and combined effect of different combination of factors on threshing efficiency were statistically analyzed and the maximum threshing efficiency of 96.7 percent and output capacity of 18.2 kg h^{-1} was achieved at 5 mm clearance, 13.5 moisture content, 7.5 ms^{-1} roller speed and at a feed rate of 180 kg h^{-1}.

3.4 Cost of economics

The cost of operating thresher was calculated by using standard procedure.

3.4.1 Cost of threshing by manual method

Weight of grain threshed by women in one hour, kg : 10
Total women hours per 100 kg : 20
Cost of women labour per day, Rs. : 200
Cost of threshing per 100 kg, Rs. : 200/8 x 20 = 500
The cost of manual threshing is Rs. : 500.

3.4.2 Cost of threshing by portable power sesame thresher

Cost of threshing per 100 kg using portable power operated sesame thresher
(considering output as 18.20 kg/h) : 39.14
Cost of threshing per 100 kg by Conventional method : 500
Saving in cost, % : 92
Saving in time, % : 72

4. Conclusion

The physical properties of *TMV 7* sesame variety were analyzed. The average length and thickness of capsules were measured as 35 mm and 12 mm. The average number of seeds in single capsule was determined as 60. The average 1000 grain weight was determined as 3.1 g. and the average size of the seed is 3×1.8× 0.9 mm. The developed portable power sesame thresher was field tested and its threshing efficiency and seed output capacity were 96.7 % and 18.2 kg h^{-1}, respectively. The saving in cost and time were 92 and 72 % respectively as compared to conventional method of manual threshing.

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