Performance Evaluation of Self-Propelled Groundnut Combine

by
T. Senthilkumar
Senior Scientist
Central Institute of Agril. Engineering, Bhopal
INDIA
thasekumar@gmail.com

D. Manohar Jesudas
Professor

D. Asokan
Professor and Head

Dept. of Farm Machinery, Tamil Nadu Agricultural University, Coimbatore
INDIA

Abstract

Groundnut is conventionally harvested either by manual pulling if the soil moisture is adequate or hoeing with hand hoe followed by manual pulling. In some places, the field is ploughed with a mould board or country plough to uproot the plants. In both methods, much of the human energy is exerted, involving drudgery and fatigue. Even groundnut harvester and thresher have become popular among the farming community during the last few years, collection and transportation of harvested groundnut plants are becoming labour intensive. This situation necessitates the introduction of groundnut combine. With this objective, a Chinese made self-propelled combine for groundnut suitable for harvesting and threshing green pods was procured and evaluated at Tamil Nadu Agricultural University and at farmer's fields in Tamil Nadu. It was observed that the average threshing efficiency was around 80.0% and the average damage to the pods was 16.10%. Modifications were done to the threshing drum and two designs of stripping drum were tested for their performance. It was observed that, stripping drum with rubber vane resulted in 94.2% threshing efficiency and 1.6% pod damages.

Introduction

India is the second largest producer of groundnut after China. Groundnut is the major oilseed in India in terms of production. On an average it accounts for 31.81% of the oilseeds. The annual production of seed and oil are 5.8 and 1.5 million tonnes, respectively. About 80% of the total groundnut produced in India undergoes processing so that it can be utilized as oil and cake. Around 75% of the crop is produced in kharif season (June-September) and remaining 25 percent in rabi season (November-March). Gujarat was the largest producer of groundnut contributing 38.14% of the total production and followed by Tamil Nadu (15.46%), Andhra Pradesh (12.25%), Rajasthan (11.55%) and Karnataka (7.44%) during 2011-12.

At present, groundnut occupies an area of 5.31 m ha in India with a production of 6.93 mt. About 91% of total groundnut area and production are confined to the states of Gujarat, Tamil Nadu, Andhra Pradesh, Karnataka, Maharashtra and Rajasthan. In Tamil Nadu, groundnut is cultivated in an area of 0.45 m ha with a production of 1.07 mt of pods. The average pod yield was 2,382 kg ha^{-1} during 2011-12. Out of the total area grown under groundnut, the irrigated rabi groundnut occupied about 37.8% during 2011-12.

Groundnut is conventionally harvested either by manual pulling if the soil moisture is adequate or hoeing with hand hoe and followed by manual pulling. In some places, the field is ploughed with a mould board or country plough to uproot the plants. In both the methods, much of the human energy is exerted, involving drudgery and fatigue. The moisture content of the soil influences the ease of harvesting in groundnut.

Yang-ren (1983) developed a small self propelled one way operation groundnut combine at Taiwan. The combine was driven by 15 hp diesel engine. An automatic hydraulic system was used to grasp the stem. In order to grip the stems out of the field, a special form of chain bar or embanking ditching belt was developed. A string type of pod stripping mechanism was attached to the combine for stripping.

Thangavelu and Swaminathan (1986) studied the performance of seven types of stripping mechanism, namely plain beater, star type, delta type, eye type, nail type and screw type for groundnut. The study revealed as that the rotor speed varied from 2.83 to 4.65 ms^{-1}, output and damage percentage were calculated at different levels of moisture content of the crop ranging from 15 to 40%. The study established that the screw type mechanism was the best.

Yang *et al*. (2009) designed and

conducted comparative test of soil removing device of peanut combine harvester. Soil removing device directly affected the performance of the follow up peanut stripping devices. Three soil removing devices were designed for the digging and pulling in peanut combine harvester viz., forward removing soil device by swaying up and down, reverse removing soil device by swaying up and down and transverse removing soil device by swaying in landscape orientation. It was observed that forward removing soil device by swaying up and down was optimal soil removing device according to the soil removal rate.

Zhichao *et al*. (2010) conducted an experiment on half feed peanut combine harvester to study stalk clamping height, clapping frequency and amplitude of clod removing unit, rotate speed of peanut picking roller, clamping chain speed, moisture content of soil and time of harvest. It was concluded that soil moisture from 8% to 15% was suitable for peanut harvesting in sandy loamy soil. Dropped peanut loss during clod removing increased gradually with the delay of harvest time. The dropped peanut loss rate was more than 2% when the snap force of peanut root was less than 5 N. The optimum stalk clamping height ranged from 150 to 200 mm, keeping total loss rate and clod content less than 6% and 4%, respectively. Lower frequency and smaller amplitude of clod clapping operation contributed to smaller dropped peanut loss rate, but higher clod content, higher frequency and larger amplitude contributed to lower clod content and higher dropped peanut loss rate. The peanut loss of peanut picking operation was kept at lower level with higher picking roller speed and lower clamping chain speed. In this experiment, loss rate of peanut picking was 2.79% at 390 rpm of picking roller speed and 0.5 m/s of clamping chain.

Even groundnut harvester and thresher have become popular among the farming community in India during the last few years, collection and transportation of harvested groundnut plants are becoming labour intensive. This situation necessitates the introduction of combine for groundnut. With this objective, a Chinese made self-propelled combine suitable for harvesting and threshing green pods of groundnut was procured and evaluated at Tamil Nadu Agricultural University and farmer's fields in Tamil Nadu.

Materials and Methods

For this study, a commercially available groundnut combine from China was purchased and evaluated in Tamil Nadu field condition (**Fig. 1**). The cropping system followed in China for this combine harvester was raised bed farming system and was shown in **Fig. 2**.

Functional Components of the Groundnut Combine

The self propelled groundnut combine harvester consists of following components:

Prime mover (or) engine

A 17.6 kW single cylinder water cooled engine is the prime mover. It consists of clutch, braking system, steering system and power transmission gear box. The steering is by hydraulic cylinder fitted to the rear wheels of the groundnut combine.

Power transmission system

The power was taken directly from the engine to all the functional components through clutch. Power for the gathering assembly was taken from the "V" belt. The power was transmitted to the chain conveying system by "V" belt. The power to the stripping system, cleaning system and pod conveying system was transmitted by using chain and sprocket arrangement.

Digging assembly

The digging assembly consists of two flat blades of 230 × 100 × 6 mm in size and an adjustable shank of 30 mm diameter mild steel rod. Provision is available to adjust the depth of operation of digging blade by adjusting the shank length.

Gathering system

The gathering system consisted of two vertical conveyors with gathering units. The width of the vertical conveyor is 80 mm. The length of each gathering unit is 140 mm. Each gathering unit is fixed at a spacing of 160 mm from each other. The gathering unit is attached with the chain drive. The two vertical gathering assemblies are spaced at a distance of 470 mm. This gathering assembly is used to collect and guide the groundnut crop to the conveying system.

Chain conveying system

The chain conveying system is used to pick up the crop, convey

Fig. 1 Commercially available groundnut combine

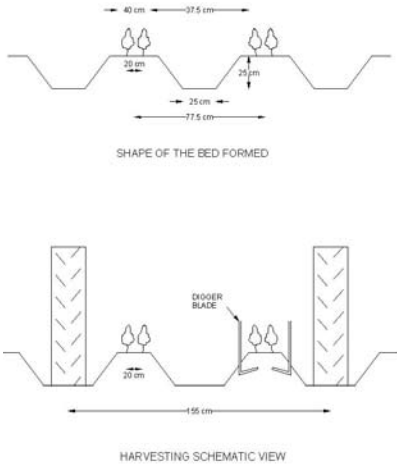


Fig. 2 Raised bed system required for harvesting by groundnut combine

Fig. 3 Groundnut crop stand in raised bed system

Fig. 4 Operational view of groundnut combine

the crop to the stripping system and discharge the stripped vines. This system consists of two endless chains which are connected to the transmission system through "V" belt. The conveying chain is fixed on the 60 × 32 mm base section of size 3760 × 310 × 160 mm.

Stripping system

The stripping system consisted of two counter rotating stripping drums of size 560 × 60 mm. On the periphery of the drum, four blades were fitted. The stripping drums were fitted below the chain conveying system, in such a way that the root position of the groundnut crop would come into contact with the revolving blades for stripping. The stripping baffles were used to strip the pods by impact force.

Cleaning system

The cleaning system consisted of a blower and a oscillating sieve. The blower was fitted at the bottom most portion of combine harvester. This was used to winnow the light foreign material from the pods. The oscillating sieve was fitted directly below the stripping system. This was used to collect the pods, to separate the clean pod and to convey the clean pods to augur conveyor system.

Pod collecting system

The pod collecting system consisted of screw conveyor, bucket elevator and collection chamber. The screw auger was fitted at the tail end of the combine harvester, nearer to the oscillating sieve. The screw augur discharged into a collection chamber from where the bucket elevator system lifted the pods. The bucket elevator system was used to lift the groundnut pods to the collecting chamber. The collecting chamber was provided with the pod collection bag holder.

Evaluation of Self Propelled Groundnut Combine

The groundnut combine was evaluated in the laboratory and field conditions for its performance. Field layout with raised bed system and crop stand is shown in **Fig. 3**. The soil and crop characteristics recorded during the testing of the groundnut combine are detailed below.

Soil parameters

The soil parameters; type of soil and moisture content of the test field were measured.

Crop parameters

The crop parameters that influence mechanical harvesting of groundnut crop were identified as plant population, root length, pod depth, crop height, pods per plant and crop moisture.

Evaluation Parameters

The self-propelled combine harvester was evaluated for harvesting groundnut crop cultivated on raised bed (**Fig. 4**). The harvesting efficiency, stripping efficiency, cleaning efficiency and percentage broken pods were measured during the evaluation of groundnut combine. The stripping drum speed directly influenced the stripping efficiency. To optimize the stripping drum speed, three levels of speed. viz., 200, 300 and 400 rpm were selected for the study.

Results and Discussions

For evaluating the self propelled groundnut combine, crop was cultivated on raised bed system. Sowing was done by using the tractor operated raised bed former cum seed drill specially developed to suit the operation of the combine harvester.

The crop stand and the other crop parameters were measured. The details of crop parameter measured are given in **Table 1**.

Trials were conducted at TNAU, Coimbatore and at Farmers field near Kinathukadavu. The results of the field observations are given in

Table 1 Crop parameters

Crop parameters	Value	Value
Variety	CO 3	TMV 7
Row spacing, mm	200 × 100 (paired row in raised bed)	200 × 100 (paired row in raised bed)
Plant population, No./ m^2	28 (conventional system – 36)	28 (conventional system – 36)
Pod depth, mm	0 to 80	0 to 65
Average crop height, mm	310	240
Moisture content of crop, %	64	68

Table 2.

From the results it was observed that, the average digging efficiency of the combine was 98% for both varieties. The average picking and conveying efficiency of conveying system was recorded as 93.5 and 92.5% for variety CO 3 and TMV 7, respectively. The total threshing losses were recorded as 20.07 and 19.75% with the average threshing efficiency of 79.90 and 80.25% for varieties CO 3 and TMV 7, respectively. The average broken pod percentage and broken kernel percentage were recorded as 18.0 and 0.73%, respectively for variety CO3 and 14.12 and 0.55% for variety TMV 7. The average field capacity of the combine was recorded as 0.12 ha/h with the average stripping capacity of 942 and 837 kg/h for varieties CO 3 and TMV 7, respectively. The average fuel consumption of the combine was recorded as 2.44 L/h.

The field trials with the combined harvester indicated that there were two major problems in the functioning of the combine. They are low stripping efficiency and damage to the pods. This is due to the plant morphology and the beater arrangement. The beater for stripping the pods is conical in shape to ensure that the pods hanging below the conveyor at different levels are stripped when they come in contact with conical stripping drum at different points as they travel along the conveyor. The crop varieties in Tamil Nadu are bunch or semi spreading type. The pods are closely clustered around the base of the plant and most of the pods are within 0-80 mm of root spread. This combine harvester is made in China and is suitable for operating in crop that are tall and pods set at the end of long roots. The high level of unthreshed pods was due to the gap between the bottom of conveyor and vanes of the stripping drum. Hence, it was decided to modify the stripping drum by

a. Increasing the number of beater vanes and reducing the peripheral speed to decrease the damage to the pods
b. Provide four vanes with rubber flaps so that higher speed of rotation is possible without causing damage to the pods.

The stripping drums were fitted with four vanes and rubber flap of 10 mm thickness and 70 mm radial height were fitted to the four vanes. The modified stripping drum with rubber flap is shown in **Fig. 5**.

The performance of the stripper drum with the rubber flap was evaluated at three levels of drum speed of 200, 300 and 400 rpm and results are given in **Table 3**.

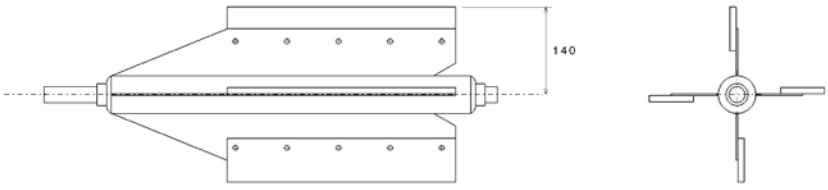
From the **Table 3**, it was observed that the stripping efficiency of 94.2% and pod damage of 1.6% could be obtained with the modified drum at drum speed of 300 rpm.

Conclusions

A Chinese made self-propelled groundnut combine suitable for harvesting and threshing green pods was procured. The combine harvester was evaluated under field

Table 2 Field performance of self propelled groundnut combine harvester

Particulars	Average values	Average values
Area covered, ha	1.55	0.82
Crop variety	CO 3	TMV 7
Height of the crop, cm	31	24
Vine pod ratio	2.6:1	3.3:1
Speed of operation, km/h	2.0	2.0
Moisture content of soil,% (wb)	15.75	17.5
Digging efficiency, %	98	98
Picking and conveying efficiency, %	93.5	92.5
Threshing losses total, %	20.07	19.75
Threshing efficiency, %	79.9	80.25
Sieve over flow, %	0	0
Broken pod, %	18.00	14.12
Broken kernels, %	0.73	0.55
Output capacity, kg/h	942	837
Field capacity, ha/h	0.12	0.12
Cost of operation, Rs/ha	2,583	2,373.5
Man power requirement, man days/ha	4	4
Fuel consumption, L/h	2.43	2.45



Side view Front view

Fig. 5 Modified drum fitted with rubber flap

Table 3 Results of laboratory test with rubber flap drums

Drum speed, rpm	Stripping efficiency, %	Pod damage, %	Unthreshed pod, %
200	85.3	5.25	14.7
300	94.2	1.6	5.8
400	87.8	8.16	12.2

conditions and the average threshing efficiency of around 80.0% and the average damage to the pods of 16.10% were observed. The average field capacity of the combine was 0.12 ha/h with the average stripping capacity of 942 and 837 kg/h for varieties CO 3 and TMV 7 respectively.

Modifications were done to the threshing drum and two designs of stripping drum were tested for their performance. It was observed that stripping drum with rubber vane resulted in 94.2% threshing efficiency and 1.6% pod damages.

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