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Design, Development and Evaluation of Tractor Operated Groundnut Combine Harvester

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Abstract: Harvesting and threshing of groundnut are the most important operations in groundnut cultivation. During peak seasons, due to the non-availability of labour in time, delay in harvesting and threshing results in heavy loss to the farmer. For alleviating the labour problems during peak seasons and for accomplishing the timeliness of operation an attempt was made to develop a groundnut combine harvester. As the combine harvester has to perform the dual operations *viz*., harvesting and threshing, the groundnut harvesting mechanism, conveyors and threshing mechanism have to be mounted integrally to carry out harvesting and threshing simultaneously. The groundnut combine with the following components should perform the desired functions. The harvester for penetrating into the soil to the required depth and digging out the groundnut crop with pods. Picker conveyor pick up units of sufficient width to allow for picking and conveying the dug out crops with pods from the soil surface. Collection chamber for collecting the crops with pods conveyed by the picker conveyor. Belt conveyor to convey the collected crop from one end of the harvester to other end. Elevator for elevating and feeding the conveyed crop with pods from the belt conveyor into the feeding chute of threshing unit. Feeding chute to regulate the flow of crops conveyed by the elevator into threshing cylinder. Thresher cylinder for separating the pods from the vines of groundnut crops. Blower for blowing out the chaff and dust particles after the threshing operation. Sieve for separation of foreign particles, vines etc., from the pods. The result of the groundnut combine harvester was obtained the maximum harvesting efficiency of 92.30 per cent, threshing efficiency of 82.30 per cent, cleaning efficiency 72.30 per cent and minimum percentage of broken pods of 4.43 for prototype tractor operated groundnut combine was observed at 1000 mm width of harvester and at 1.5 km h^{-1} forward speed of operation. The operation of groundnut combine harvester resulted in 39.00 and 96.00 per cent saving in cost and time respectively, when compared to conventional method of manual digging and stripping.

Key words: Groundnut digger, picker conveyor, flight elevator and groundnut thresher, combine harvester, field efficiency

INTRODUCTION

Harvesting and threshing of groundnut are the most important and labour intensive operations in groundnut cultivation. Present practice of manual harvesting and threshing consumes huge amount of labour to the magnitude of 84 man-h ha^{-1}[1]. During peak seasons, due to non-availability of labour in time, delay in harvesting and threshing resulted in heavy loss to the farmer. In addition, the migration of agricultural labour force from the rural areas aggravated the problems to the farmers. One of the solution for increasing the profit and productivity is to mechanize both harvesting and threshing operations in groundnut cultivation. For mechanizing these operations, power operated groundnut harvesters, and ground threshers have been developed. Even though the harvesters and threshers have been developed, their adoption level is very low due to varying power requirements and individual operation leads to the requirement of separate machine. Hence a machine similar to the rice/wheat combine is the present need of the farmers through which harvesting and threshing of groundnut crop could be taken up simultaneously. Sensing the success of rice/wheat combine, the development of a tractor operated groundnut combine was contemplated.

MATERIALS AND METHODS

The main frame consists of a rectangular section with two support frame mounted. These support frames were extended beyond the main frame (Fig.1). At the rear end of the support frames, the picker conveyor, collecting chamber, flight elevator and groundnut thresher were

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mounted. At the rear ends of the support frames, two depth control cum transport wheel were provided with necessary support structures. The height of the wheel can be adjusted to control the depth of penetration of harvesting blade into the soil. All the other functional components were attached with the main frame. In the front portion of the main frame a reduction gearbox with 1: 2.5 ratio was mounted. The drive to the gearbox was transmitted from tractor PTO, through telescopic shaft with universal joint. The gearbox output shaft is extended on one side of the mainframe and a double groove 'V' pulley was mounted for transmitting drive to the thresher assembly.

Harvesting Mechanisum:

Harvester Blade: The components of the groundnut harvester included harvesting blade. The groundnut harvester consists of 1000 mm straight shape tool with sharp edge at front end. The tool was rigidly fixed with main frame at both ends with support arms.

Picker Conveyor: The picker conveyor assembly consists of a pair of reel chain, picker bar, picker pegs and power transmission pulleys. The picker conveyor was mounted on the support frame at a distance of 1250 mm from the frond end. The drive pulley of picker conveyor was clamped to the support frame with extension arm. Each endless reel chain was rotating on a pair of pulleys fixed with necessary support on both side of the support frame. Picker bar made of 25 mm dia mild steel pipes of 1000 mm length were fixed on the reel chain links. 20 numbers of picker bars were spaced at 80 mm. On each picker bar 8 numbers of picker rod made of 6 mm mild steel rod fixed at distance of 150 mm. The top end of the picker conveyor was rigidly fixed with main frame whereas bottom drive was supported from the chains attached to the top of the frame. The drive for the picker conveyor, the power was transmitted from the thresher input shaft.

Collecting Chamber: The collecting chamber was used for the collection of the picked and conveyed harvested produce. It was provided at the rear side of the picker conveyor. The crop collecting chamber consists of a trapezoidal hopper with a flat rubber belt conveyor. The trapezoidal box was made of 2 mm mild steel sheet to bend the required size. The top width of section 1000 mm and bottom of width of 300 mm. The harvested produce conveyed by picker conveyor was dropped into the trapezoidal section of collecting chamber. The slope of the section enables to easy flow of the produce on to the flat belt conveyor. An endless rubber belt of 300 x 5 mm thickness was provided at the bottom section of the trapezoidal hopper. The belt was supported by two wooden rollers at both the ends and runs across the width of the main frame. The power for the roller was transmitted from the picker conveyor shaft through bevel gear transmission. The harvested produce that fall on the flat belt conveyor were conveyed to one end of the flight elevator bottom end.

Flight Elevator: The flight elevator was used to elevate the harvested produce from the collecting chamber to the required height for feeding into the feeding chute of thresher. The assembly consists of a rubber belt conveyor, flight with picker pegs, steel rollers and shield. A flat rubber belt of 300 mm width and 5 mm thickness and height of 2250 mm was provided from the bottom portion of the collection chamber. The belt runs on two steel rollers of 200 mm dia provided at top and bottom of the flight elevator frame. On the surface of belt, flights (picker rods) made of mild steel flats and 6 mm mild steel rod assembly were fixed. The entire belt assembly was covered with the shield to prevent spillage of produce in elevator.

Thresher: A groundnut thresher for threshing high moisture groundnut crop was fabricated. The threshing consists of major components like thresher frame, feeding chute, cylinder and concave assembly, cleaning sieves and blower.

Thresher Frame: The frame was fabricated to accommodate the cylinder concave assembly, cleaning sieve, blower and power transmission system. The frame was made of 30 x 60 mm mild steel angle section. The overall size of the frame was 2050 x 1650 x 1570 mm. The thresher frame was mounted on the support frame.

Feeding Chute: A feeding chute of 350 x 200 mm made of 1.5 mm mild steel sheet was fitted at one end of the concave with a slope of 40 deg to the horizontal.

Threshing Cylinder: The drum type threshing cylinder 400 mm diameter and 100 mm length was made of 3 mm mild steel sheet. Based the previous research work, the cylinder surface was provided with flat pegs with curved edge to eliminate clogging of feed material at high moisture content. The length of the peg was 70 mm and arranged in ten rows such that each row has 7 to 8 pegs. As the pegs were fixed in a row, the position of all pegs in a row can be raised or lowered for the adjustment of concave clearance. A concave made of 6 mm mild steel rod with inner diameter of 610 mm and sieve hole size of 80 x 30 mm was provided covering the half circumferential area of cylinder. It has an inlet opening of 230 x 140 mm and an outlet opening of 270 x 210 mm at two ends of the concave. On the inner side of top surface of concave, three helical louvers were provided at a spacing of 250 mm to give axial flow movement to the crop materials.

Cleaning Sieves: In axial flow thresher, the entire crop is being subjected to threshing action in between the cylinder and concave. In the process of stripping of pod from crop, the leaves, vines and soil sticking on the root also get separated and passed through the concave to the cleaning sieves. To separate all these unwanted material from the pod, two sieves were fitted below the concave. The top sieve has sieve holes of size 50 x 17 mm and driven by an eccentric shaft with 20 mm radius. Due to the rotation of eccentric shaft, the sieves get reciprocating as well as up and down motion for easy lifting and moving of materials moving on it. Similarly the bottom sieve has holes of size of 25 x 9 mm and is driven by an eccentric shaft with 12 mm radius.

Blower: A centrifugal blower with spiral casing was provided in between the two cleaning sieves, for blowing of light weight crop material coming along with threshed pod from concave. The blower fan has 4 paddles and a dia of 250 mm. The paddles have a width of 85 mm and fixed to main shaft with the help of three hubs and angle iron supports. The clearance between blade tip and spiral casing varies from 6 to 15 mm. The size of the blower out let was kept as 900 x 10 mm. The blower speed was maintained to develop an air velocity of 6 m s^{-1}, which was less than the terminal velocity of groundnut pod and more than that of leaves and other crop materials.

Performance Evaluation of Groundnut Combine Harvester: The evaluation parameters selected are harvesting efficiency, threshing efficiency, cleaning efficiency and percentage broken of pods were determined.

Harvesting efficiency: The harvesting efficiency was calculated by using the following formula:

$$\eta_h = \frac{W_p}{(W_p + Ws)} \times 100$$

Where,

h_h = Harvesting efficiency, per cent
W_p = Weight of harvested crops collected from the soil in one square meter area, kg
Ws = Weight of left out crops collected from the soil in one square meter area, kg

Threshing Efficiency:

$$E_t = \frac{W0}{W_I} \times 100$$

Where:

E_t = Threshing efficiency, per cent
W_0 = Weight of pods collected from all outlets per unit time, kg
W_I = Weight of input pods per unit time, kg

Cleaning efficiency: The cleaning efficiency of prototype groundnut combine harvester was worked out based on the following expression.

$$E_c = \frac{W_m - W_F}{W_m} \times 100$$

Where:

E_c = Cleaning efficiency, per cent
W_F = Weight of foreign matter collected in main out let per unit time, kg
W_m = Weight of sample collected from main pod outlet per unit time, kg

Percentage of broken pods: The percentage of broken pods was calculated by using expression

$$B_p = \frac{W_b}{W_I} \times 100$$

Where:

B_p = Percentage of broken pods.
W_b = Weight of broken pods collected from main outlet of thresher per unit time, kg.
W_I = Total weight of pods per unit time, kg

RESULTS AND DISCUSSIONS

The prototype groundnut combine harvester was evaluated in red sandy loam soil at 15.68 per cent soil moisture. The measured values of bulk density and cone index of the soil were 1.47 and 15.68 respectively. The crop parameters measured during the evaluation of prototype combine are furnished in table 1.

Table 1: Crop parameters measured values

Sl.No	Crop parameters	Value
1	Variety	CO-1
2	Row spacing, mm	30 x 10
3	Plant population, No./m^2	40
4	Pod depth, mm	58.6
5	Crop height, mm	268.3
6	Number of branch vines, No.	6
7	Pods per plant, No.	14
8	Pod vine ratio	0.365
9	Bulk density, gcm^{-3}	0.81
10	Moisture content of crop, %	72.59
11	Force required to pull the root portion of crop from soil, kg	5.08

The combination of 1000 mm width of harvester and forward speed of 1.5 km h^{-1} resulted in maximum harvesting efficiency of 92.3 per cent, threshing efficiency of 82.3 per cent, cleaning efficiency 72.3 per cent and minimum percentage of broken pods of 4.43 per cent. Field capacity of 0.15 ha h^{-1}, theoretical field capacity of 0.198 ha h^{-1} and Field efficiency 75.75%.

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