Development of a Prototype Tractor-operated Groundnut Digger-Lifter

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Key words: Tractor; groundnut; digger-lifter.

ABSTRACT

Digging or pulling groundnuts from the ground is a laborious and time consuming hand operation. The use of a mechanical digger will reduce the labour requirement and minimise the drudgery. This paper describes the development and fabrication of a prototype groundnut digger-lifter based on a potato digging machine. The design consists of two digging blades which penetrate under the plant row to loosen the soil and cut the tap root. There are lifting rods on the blades which help lift the plants from the soil and elevate them to the conveyor. The conveyor performs the tasks of separating, shaking and elevating the plants to a discharge unit. The conveyor is powered from the tractor PTO. The power is transmitted to the conveyor shaft through a chain sprocket transmission system. From preliminary tests carried out, at a speed of 0.9km/hr, the machine has a working capacity of 0.5ha/hr with an efficiency of 63%. The estimated output per hectare is 126kg of peanuts.

INTRODUCTION

Groundnuts (Arachis hypogaea L) called peanuts in many part of the world has been described as a promising diversification crop for Malaysian agriculture because of its agronomic and economic potential and has been recommended as an attractive short-term cash crop for estates and small holder farms for interplanting with permanent crops (RRIM, 1974).

Groundnut varieties cultivated in Malaysia are mostly of the Spanish type which feature an upright stem. As groundnuts are mostly grown in sandy soil or silt sandy loam, manual harvesting by pulling out the stems has been possible. According to Hwang (1983) the optimum stem grip position is 5 to 15cm above the ground. No statistical data was available to ascertain whether the grip position is significant.
Harvesting of groundnuts involves a large labour force at present. Pulling and picking the pods would take 84 man hours per hectare or 6.4 man hours per 100kg. Experience overseas reveals that tractor operated harvesting equipment could reduce the labour requirements from 1/12 to 1/30 compared to traditional practices (Kalkat, et al., 1978).

Mechanisation of groundnut planting, harvesting and shelling in Malaysia is still in its infancy in contrast to farmers in the developed countries. Factors that hinder the application of modern technology are many. Apart from the socio-economic constraints, there is the problem of developing a suitable machine for local conditions.

EXISTING HARVESTING SYSTEM

The various ways of harvesting groundnuts at present can be categorised into three groups: one, is for small areas under present farming conditions where the groundnuts are lifted by hand and the nuts picked off the plants and shelled manually. Two, is for medium sized areas where some of the operations are done by machinery particularly the lifting, picking and shelling; three is for the large commercial growers who employ expensive, specialised machinery to mechanise all operations. The division between these three systems — manual, partly mechanised and fully mechanised — is not always clear cut as some simple tools may be introduced for an operation while manual harvesting continues. On the other hand, some manual work may be needed in a “fully mechanised” system.

DEVELOPMENT OF GROUNDNUT HARVESTER

Two factors which are mainly responsible for the increased interest in the development of a mechanical groundnut harvester are rising harvesting costs and the shortage of human labour. In 1978, harvesting cost was $250/ha while in 1980, it had increased to $625/ha which accounted for about half of the total production cost (Zohadie and Wan Ishak, 1981).

In the development of the experimental digger-lifter, the criteria for design were:

i) low capital costs
ii) low operating costs
iii) usage of local materials wherever possible
iv) affordability by small groups of farmers
v) easy control and maintenance by farmers without a high level of technical knowhow.
vi) adaptability to changing circumstances.
vii) minimisation of labour shortage during peak production period.
viii) increased productivity and income for farmers.
ix) local fabrication
x) ability to utilise idle tractors during paddy off season.

Design Considerations

The groundnut digger-lifter was designed for bunch varieties as they are more suitable for mechanised inter row cultivation. Accordingly the objective for the machine was to dig and lift bunch or semi-bunch varieties of groundnuts and deliver clean plants into a loader or trailer. Further, the machine must have the capacity to harvest enough groundnuts in one month (the normal harvesting period) to be feasible for a holder of that size to economically purchase it. The operational machine would carry out three distinct operations, namely:

i) loosen the soil and cut the tap roots
ii) lift the plants onto a conveyor and
iii) separate the plants from soil clods and finally discharge them into a loader.

Plate 1 shows the groundnut-digger-lifter while Figures 1, 2 and 3 show the schematic drawings. Design specifications are as given in Table 1. Detailed calculations on the dimensions selected are presented in separate reports (Shamsudden Ghanny 1984) and Mokhtar Zakaria, 1986).

Digging Blade. Groundnut digging requires a blade with the cutting edge angling forward at about 25 degrees to achieve scouring and penetration. The cutting knife runs about 10cm deep to cut the tap roots and loosen the soil around the nuts since mature nuts on a bunch variety are usually concentrated around the tap root within a depth of about 10cm. The digging blades are mounted on the main frame of the lifter by bolts and locking nuts as shown in Figure 1.
DEVELOPMENT OF A PROTOTYPE TRACTOR-OPERATED GROUNDNUT DIGGER-LIFTER

TABLE 1
Design specifications

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1. Blade cutting angle</td>
<td>25°</td>
</tr>
<tr>
<td>2. Depth of cut</td>
<td>15cm</td>
</tr>
<tr>
<td>3. Length of cut</td>
<td>26cm</td>
</tr>
<tr>
<td>4. Length of leg support</td>
<td>61cm</td>
</tr>
<tr>
<td>5. Thickness of leg support</td>
<td>1.9cm</td>
</tr>
<tr>
<td>6. Width of cut</td>
<td>107cm</td>
</tr>
<tr>
<td>7. Design speed</td>
<td>1.8km/hr</td>
</tr>
<tr>
<td>8. Drawbar horsepower at work</td>
<td>20HP</td>
</tr>
<tr>
<td>9. Length of conveyor chain</td>
<td>336cm</td>
</tr>
<tr>
<td>10. Plate spacing</td>
<td>15cm</td>
</tr>
<tr>
<td>11. Shaker spacing</td>
<td>18cm</td>
</tr>
<tr>
<td>12. Speed of conveyor</td>
<td>0.5m/s</td>
</tr>
<tr>
<td>13. Total length of machine</td>
<td>216cm</td>
</tr>
<tr>
<td>14. Width of machine (from wheel centre to centre)</td>
<td>153cm</td>
</tr>
</tbody>
</table>

Plate 1: Groundnut Digger-Lifter

Power Requirement for Blade and Implement. Power requirement depends on the draught force developed and the forward speed. The blade rake angle (angle between the blade and soil surface) has a significant effect on the draught force. Earlier studies (Spoor, 1969) have shown that the draught force increases gradually from rake angle of 10° to 50° but above 50° the rate of increase is very steep indeed due to compression. Therefore for minimum draught, a rake angle of less than 50° must be used.

Conveyor. Review of past work (Shamsudeen Ghanny, 1984) shows that a shaker must be 138cm wide to handle bunch groundnuts in 86 to 92cm rows and should raise the groundnuts to 122cm distance to shake and windrow them effectively under many conditions. The conveyor plate should be spaced 15cm apart with shakers using spike arrangement fixed to the elevator chain for effective lifting and shaking. This elevator arrangement helps to lift and separate the soil clods from the bunch of groundnuts. Shamsudden Ghanny also reported that for...
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TABLE 2
Average results of two readings obtained for two PTO speeds

<table>
<thead>
<tr>
<th>PTO (rpm)</th>
<th>$W_k$ (kg/hr)</th>
<th>$W_o$ (kg/hr)</th>
<th>$W_h$ (kg/ha)</th>
<th>$W_i$ (ha/hr)</th>
<th>$\Sigma_i$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6000</td>
<td>65.5</td>
<td>40.7</td>
<td>11.3</td>
<td>0.6</td>
<td>61.9</td>
</tr>
<tr>
<td>700</td>
<td>75.0</td>
<td>48.3</td>
<td>138.7</td>
<td>0.5</td>
<td>64.4</td>
</tr>
</tbody>
</table>

Type of soil : Serdang series
Soil moisture content: 13.3% (dry basis)
Soil bulk density : 1287.1 kg/m$^3$
Tractor-forward speed: 0.9 km/hr
Slip : 14.9%

Notation
$W_k$ = weight of peanuts lifted in an hour (kg/hr)
$W_o$ = weight of broken peanuts in an hour (kg/hr)
$W_h$ = machine output (kg/ha)

$W_p$ = machine working capacity (ha/hr)
$E_k$ = machine efficiency

$$E_k = \frac{(W_p - W_i - W_o)}{W_p} \times 10$$

Where:
$W_p$ = Total weight of peanuts harvested (kg)
$W_i$ = Total weight of broken peanuts (kg)
$W_o$ = Total weight of peanuts not lifted (kg)

Effective operation it is desirable to have a conveyor speed of 0.5m/s.

Transmission System. The tractor PTO power was transmitted through a system of sprockets and chain. Two sprockets of 2.5cm pitch and 12cm diameter were used in addition to a set of speed reduction gears.

Performance Tests. Several tests were carried out at the University Farm. Data obtained are as shown in Table 2. From the results the machine was capable of harvesting 0.5ha in an hour at a speed of 0.9km/hr. The efficiency based on total weight harvested minus the broken and unlifted nuts was 63%. The results also indicate that the machine would be able to harvest 126kg of peanuts per hectare given a uniform condition.

In an effort to improve the efficiency of this machine the design of a new conveyor system is currently being studied.

REFERENCES

HWANG, YANG-REN. (1983): Development of Peanut Combine Harvester. Agricultural Mechanisation in Asia, Africa and Latin America (Japan. 14(2): 188-

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(Received 29 May, 1984)