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Development and evaluation of mechanical earthing up equipment for groundnut crop

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■ **ABSTRACT :** Groundnut is the major oil seed crop in India and it plays a major role in bridging the vegetable oil deficit in the country and also serves as a protein supplement to animals in term of feed. Lower penetration of groundnut pegs and weeds grown with the crop are the responsible for drastic reduction of yield. Earthing up destroys weeds and increases pod development by increasing penetration of pegs in the soil. But traditional methods of earthing up are tedious, laborious, and time consuming which leads to high cost of production. Pertaining to this, a simple mechanical earthing up equipment was developed and evaluated under groundnut crop at two operating conditions *i.e.*, 2 and 4 rows at a time. The results obtained at 2 rows and 4 rows earthing up condition were the earthing up efficiency (96 and 93 %), plant damage (1.96 and 3.5 %), effective field capacity (0.096 and 0.126 ha/h), field efficiency (80 and 52.5 %), fuel consumption (4.72 and 3.96 L/ha) and cost of earthing up (628.67 and 500 Rs./ha), respectively.

■ **KEY WORDS :** Development, Earthing up, Evaluation, Groundnut, Mechanical earthing up

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Groundnut (*Arachis hypogaea* L.) also called as peanut, earthnut, monkey nut, pinda, goober and manila nut (Rakulane *et al.*, 2016) is belongs to the family Fabaceae and widely grown in the tropics and subtropics (Anonymous, 2016). It ranks as 13th important crop in the world (Ahmad *et al*., 2015). It is an oilseed crop with 40-50 per cent oil content (in addition to cooking, groundnut oil is being used in industries to produce soap, cosmetic cream, plasters and oilment) and the remaining portion can be used as meal for food or feed as protein supplement (25-30 % protein) in animal feed (Vara Prasad *et al*., 2010). World annual production of shelled groundnut was 28.46 million tonnes in 2013-14 from the area of 24.41 million ha with the average yield of 1.17 t/ha (Anonymous, 2015a). India ranks second globally after china in production (with 11 % share to the global output in 2013-14 from 5.54 million ha of harvested area).

Groundnuts account for about a quarter of all oilseeds produced in the country and Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra are the main groundnut producing states in the country. Around 75 per cent of the crop is produced in *Kharif* (June-September) and remaining 25 per cent in *Rabi* (November-March) (Vara Prasad *et al*., 2010). Sowing of groundnut should be done about 5 centimeters deep behind the plough or with the help of dibbler or seed planter (which can be used for large scale). Seed rate of 120 to 125 kg kernels per ha and spacing of 30 to 40 cm between rows and 10 cm between plants is

recommended for row cropping practice (Okello *et al*., 2013 and Anonymous, 2015b). In developing countries, productivity of groundnut is generally low compared to those from developed countries like the USA, because of a combination of factors such as non-irrigated cultures, traditional small-scale farming with little mechanization, outbreaks of pest infestations and diseases, poor adoption of agronomic practices etc. (Okello *et al*., 2013).

Weeds cause much damage to the groundnut crop during the first 45 days of its growth. The most critical period of weed competition is from 3-6 weeks after sowing. The average yield loss due to weeds is about 30 per cent, whereas under poor management yield loss by weeds may be 60 per cent. Therefore, it is advantageous to mechanically and/or chemically control weeds during the initial 6 weeks of groundnut growth (Anonymous, 2015c). Earthing-up is an essential operation in groundnut cultivation to enhance the productivity by destroying the weeds and increasing penetration of pegs in the soil thereby increased pod development (Ahmad *et al*., 2015 and Anonymous, 2015b). Hence, earthing up is to be done within 40-45 days after sowing. In India, the earthing up operation is being done traditionally using improved long handle hoes, working star type weeder and in many instances using country plough. It is well known fact that, all these methods are laborious, tedious and time consuming practise. Hence there is a need to introduce a mechanical multi row earthing up equipment for groundnut crop.

By considering the above fact as an objective of this paper, a simple mould board type mechanical multi row earthing up equipment was developed and evaluated under the groundnut crop field as an attachment to the customized propelled IC engine [single cylinder, 3 hp dual powered (petrol start kerosene engine) and pegged wheels].

METHODOLOGY

The development of mechanical multi row earthing up equipment for groundnut crop was carried out in the department of Agricultural Engineering, University of Agricultural Sciences, GKVK, Bangalore. The performance of the developed equipment was evaluated in the university farm where the soils of the site belong to the red sandy loam with good moisture retention and infiltration rate. The main aim of the developed mechanical earthing up equipment was to invert the weeds and earthing up the crops without or with very negligible crop damage and with least cost of earthing up operation.

The factors considered while developing the mechanical multi row earthing up equipment were the variety of crop, its cropping pattern (row to row spacing), height of crop at the time of earthing up, average root zone area of crop, time of earthing up after sowing/ planting, height of earthing up, etc. The mould boards of the equipment were made from mild steel sheet of 0.4 cm thickness. The main components of the earthing up equipment were shown in Fig. A and B. The specification of the developed earthing up equipment is given in Table A.

The parameters recorded before earthing up operation were the crop parameters (variety of crop,

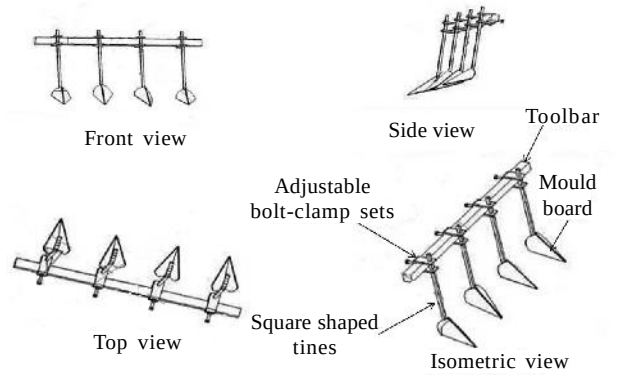

Fig. A : Schematic diagram of developed mechanical multi row earthing up equipment

Table A : Specifications of developed mechanical multi row earthing up equipment

Sr. No.	Components	Description/Dimension	Construction material
1.	Power source	3 hp petrol start kerosene IC engine	-
2.	Tines	Square rod (2×2 cm) of 50 cm length	Mild steel
3.	Mould board	Triangular shape of two metal (0.4 cm thickness) welded in such a manner to form mould board	Mild steel sheet
4.	Tool bar	Square hollow pipe (5 cm × 5 cm) of 0.5 cm thickness and 120 cm length	Mild steel
5.	Bolt-clamp set	U-shaped clamps having dimensions as same as tool bar with bolting arrangement for adjusting depth and width of earthing up by moving tines accordingly	Mild steel

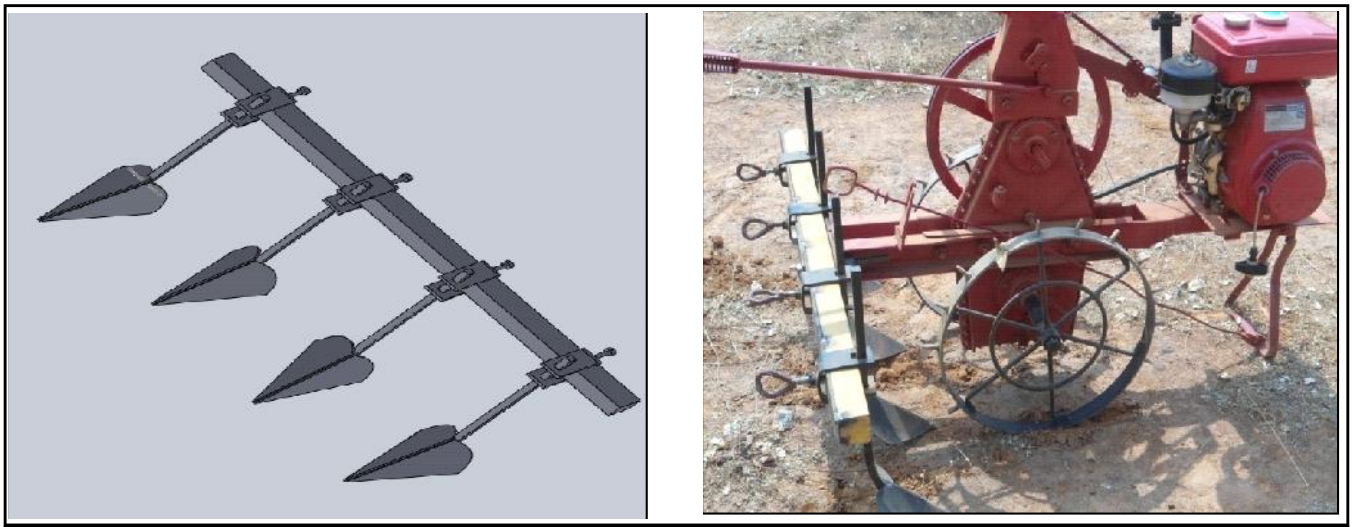

Fig. B : 3-D view of solid model developed using CAD software (left) and assembled view (right) of mechanical multi row earthing up equipment

plants height and row to row spacing) and field parameters [type of soil, moisture content (MC), bulk density (BD) and cone index (soil strength) of soil and length and width of the field]. The plants height was recorded by measuring the height of the crop randomly in the field. Row to row spacing and length and width of the field were measured directly by using standard measuring tape. The soil was sampled (core sampled incase of BD measurement) randomly at different places within the experiment field to determine the MC and BD of the soil. Gravimetric method was used for moisture determination (Bethlahmy and Nedavia, 1952) and weight by volume method (Blake, 1965) was used for bulk density measurement. The cone penetrormeter method was used to determine the cone index (soil strength) of the soil. The following formulas were used to determine the MC, BD and cone index of the soil, respectively.

$$MC = \frac{w_1 - w_2}{w_1} \times 100 \quad (1)$$

$$BD = \frac{m}{V} \quad (2)$$

$$CI = \frac{F}{A} \quad (3)$$

where

MC= Moisture content in wet basis, per cent

W_1= Weight of the wet sample, g

W_2 = Weight of the oven dry sample, g

BD= Bulk density of soil, g/cm^3

m= Weight of core sampled soil after laboratory drying, g

V = Volume of cylinder core, cm^3

CI = Cone index, kg/cm^2

F = Force applied detected in penetrormeter, kg

A = Area of cone base, cm^2

The performance of earthing up equipment attached to the single cylinder IC engine (3 hp petrol start kerosene engine) was evaluated under the groundnut crop field (40 days after sowing) at two operating conditions (two and four row earthing up condition) to determine their effects on earthing up efficiency, plant damage, effective field capacity, field efficiency, fuel consumption and cost economics of earthing up operation. The forward speed of mechanical equipment at earthing up was maintained constant by placing the acceleration throttle knob to its full range (forward speed of earthing up equipment at no load condition was recorded as 2 km/h at acceleration throttle in full range).

The earthing up efficiency and plant damage (Goel *et al*., 2008; Gavali and Kulkarni, 2014 and Kumar *et al*., 2014) in per cent were calculated by using equations given below.

$$EE = \frac{p_1 - p_2}{p_1} \times 100 \quad (4)$$

$$PD = \frac{n_1}{n_2} \times 100 \quad (5)$$

where

EE = earthing up efficiency, per cent

p_1 = Number of visible pegs of the groundnut crop

on the surface before earthing up

p_2 = Number of visible pegs of the groundnut crop on the surface after earthing up

PD = Plant damage, per cent

n_1 = Number of injured plant in 10 m row length after earthing up

n_2 = Total number of plant in 10 m row length before earthing up

The effective field capacity, field efficiency and fuel consumption of the mechanical earthing up were determined by using following equations (Alizadeh, 2011; Silas and Abu, 2015 and Hossen *et al*., 2015).

$$EFC = \frac{\text{Area covered (ha)}}{\text{Time taken (h)}} \quad (6)$$

$$\eta = \frac{\text{Effective field capacity}}{\text{Theoretical field capacity}} \times 100 \quad (7)$$

$$F_c = \frac{\text{Fuel consumed while weeding (lit.)}}{\text{Area covered (ha)}} \quad (8)$$

where

EFC = Effective filed capacity, ha/h

η = Field efficiency, per cent

F_c = Fuel consumption, lit./ha

The cost of earthing up operation was calculated by using standard procedure. The necessary assumptions were made (which includes bill of material used for development of earthing up equipment, fixed and operational cost of engine, labour cost and fuel cost) wherever it seems essential to analyze cost of earthing up operation.

RESULTS AND DISCUSSION

Prior to actual mechanical earthing up, few important parameters were recorded and presented in the Table 1. The results obtained from performance evaluation of the mechanical earthing up under the two rows and four rows earthing up condition are presented in Table 2 and discussed below. The forward speed achieved under full acceleration at 2 rows and 4 rows earthing up operation were recorded as 1.6 km/h and 1.05 km/h, respectively. The maximum speed of the engine at no load condition with full acceleration was recorded as 2 km/h. The theoretical field capacity of the mechanical earthing up were 0.12 and 0.24 ha/h, respectively at forward speed of 2 km/h for 2 rows and 4 rows (60 cm and 120 cm width, respectively) of earthing up. The depth of 6 cm and width of 18 cm per MB bottom were observed and recorded for both 2 and 4 rows of mechanical earthing up.

It was observed from Table 2 that the earthing up efficiency was highest for 2 rows earthing up condition accounting about 96 per cent with less plant damage (about 1.96 %) as compared to 4 rows earthing up which has little high plant damage and less earthing up efficiency (of about 3.5 % and 93 %, respectively). The reason for this lower earthing up efficiency and higher plant damage under the 4 rows earthing up condition may be due to instability of operator that caused by heavy load on equipment which made operator incapable to handle the equipment firmly. Srinivas *et al*. (2010); Kumar *et al*. (2014) and Hossen *et al*. (2015) were reported similar trend while evaluating of their mechanical weeder.

The effective field capacity was found highest for 4 rows earthing up but as shown in Table 2, the field efficiency, fuel consumption, and cost of operation were found highest for 2 rows earthing up. The reason for this higher field capacity, less fuel consumption and less cost of operation of 4 rows earthing up was that the number of rows earthed up in a single pass was just double the number of rows earthed up in 2 rows earthing up condition. The reason for this least field efficiency under 4 rows earthing up as compared to 2 rows earthing

Table 1 : Parameter recorded before mechanical earthing up operation

Sr. No.	Parameter	
1.	Type of soil	Red sandy loam
2.	Moisture content of soil, per cent	16.2
3.	Bulk density of soil, g/cm^3	1.45
4.	Cone index of soil, kg/cm^2	2.58
5.	Variety of crop	DH 3
6.	Plant height, cm	18.6
7.	Row to row spacing, cm	30
8.	Length and width of field, m	28 × 20

Note: All values in the table are average of four replications

Table 2 : Results obtained from performance evaluation of mechanical earthing up

Sr. No.	Parameters	Earthing up condition	
		2 rows earthing up	4 rows earthing up
1.	Earthing up efficiency, %	96	93
2.	Plant damage, %	1.96	3.5
3.	Effective field capacity, ha/h	0.096	0.126
4.	Field efficiency, %	80	52.5
5.	Fuel consumption, L/ha	4.72	3.96
6.	Cost of earthing up, Rs./ha	628.67	500

Note: All values in the table are average of four replications

up was may be that the wheel slip occurred due to heavy load and excessive time lost during turning at the end of the field. The results of field capacity, field efficiency and fuel consumption of mechanical intercultural equipment were matched with results of Srinivas *et al*. (2010), Hegazy *et al*. (2014); Kumar *et al*. (2014) and Hossen *et al*. (2015).

It found from Table 2 that the cost of earthing up was highest for 2 rows operation as compared to 4 rows operation. The time required and fuel consumption per unit area for earthing up was highest for 2 rows earthing up operation as compared to 4 rows operation. As a result, cost of earthing up was found higher for 2 rows operation. The essential assumptions made for calculation of cost of earthing up operation were total fixed cost of equipment, cost of fuel (kerosene *i.e*., Rs. 40/lit.) and operator cost (Rs. 25/h).

Conclusion :

It can be concluded that the 4 rows mechanical earthing up can be recommended to earthing up the groundnut crop as it is useful in inverting weeds as well as earthing up the groundnut plants and has higher field capacity, lower cost of earthing up with earthing up efficiency and plant damage of 93 and 3.5 per cent, respectively, which are comparable to the conventional earthing up operation.

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