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Does groundnut mechanization improve the energy use efficiency and productivity of groundnut?

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Abstract
Groundnut is a labour-intensive crop, especially in traditional method of groundnut cultivation, a greater number of labour force is required for operations like sowing, weeding and harvesting. Thus, results in high cost of cultivation and high energy usage. Increasing energy use efficiency and reducing cost of cultivation in groundnut cultivation is challenging one. Mechanized groundnut cultivation is pre-requisite to replace the high labour-intensive traditional method of groundnut cultivation. In India, very few research has been done in the energetics of mechanized groundnut production. Thus, a field study was carried to work-out the energy requirements for groundnut production under mechanized sowing, weeding and harvesting using energy equivalents in order to view and identify the suitable implement package with high energy efficiency and profitability to the farmers. The results highlight that a total input energy of 13109 MJ/ha was required by the conventional method of cultivation whereas in improved mechanization method required a total input energy of 11515 MJ/ha is required. The groundnut mechanization package involves, use of improved implements consisting of hand push seeder for sowing, power weeder for weeding, groundnut digger for harvesting and power operated stripper for pod stripping which results in higher energy ratio of 12.86 compared to conventional method of cultivation consisting of manual sowing, hand weeding, pullout and pod stripping manually results in lower energy ratio of 9.79.

Keywords: Hernia, buffalo bull, umbilical, herniorrhaphy

Introduction
Groundnut (*Arachis hypogea* L.) is a significant oil seed crop of India belongs to the Fabaceae family. Groundnut plays an important role in the oil economy of India. Groundnut kernel contains 45% oil and 26% protein. In dryland agriculture, soil moisture availability is limited to a short period of time, timely sowing is crucial for good crop establishment. Traditional methods of field operations require high number of labours and more time results in increase in cost of cultivation and energy requirement. Crop cultivation during peak season faces the problem of labour scarcity which results in delayed sowing, weeding and key operations which in turn invites the problem of low productivity (Nirmala Devi, 2020) [10]. Hence, to overcome the labours shortage and to perform the field operation at right time to utilizes the limited resources in dryland condition, the farmers can go for mechanized crop cultivation. Mechanization plays the major factor in reducing the cost of cultivation, improving the energy use efficiency and performs timely field operations with high precision. Groundnut is a labour-intensive crop which involves high cost of cultivation. Mechanized crop production is essential to reduce the labour and reduce the cost of cultivation in groundnut (Govindaraj and Mishra, 2011) [3]. By scientific intervention on mechanizing groundnut cultivation the twin objective of higher productivity and energy use efficiency may be achieved (Harisudan and Subrahmaniyan, 2020) [4].

Groundnut is sown conventionally by manual labours through dibbling and sowing behind the country plough. Traditional method of sowing is a time-consuming process involves high number of labours incurring high cost of cultivation (Awadhwal and Babu, 1994) [1]. So, mechanized sowing is the need of the hour. By mechanized sowing, we can cover large area per unit time and precised spacing is maintained (Mohanty *et al*., 2017) [8].

Another important factor in groundnut cultivation is weeds which create a major problem in production and productivity. In groundnut, the loss in yield ranges from 13 per cent to 100 per cent depending on the season, cultivar, weed competition and package of practices adopted. (Yaduraju *et al.*, 1980; Kalaiselvan *et al.*, 1994; Devidayal and Ghosh, 1999) [13, 2, 5].

Weed management plays a significant a role in crop production and decides the success of the crop. Hand weeding and herbicide application are now commonly practiced methods for eliminating weeds. Tractor drawn weeder will cover 4- 5 ha/ day and large area will be weeded in limited time (Govindaraj and Mishra, 2011) [3].

In groundnut, harvesting is the major operation involves high number of labours and results in high cost of cultivation. After harvesting, manual stripping is the major problem involves high number of labours and time-consuming process. Mechanized harvesting is possible through groundnut digger, shaker cum windrower, groundnut fresh pod thresher, groundnut fresh pod stripper, dry pod thresher and groundnut combine harvester. Groundnut strippers are very useful and combined harvester will finish the post harvesting process as easier (Madhusudhana, 2013) [6].

According to Mittal (1984) [7], the total energy needed for groundnut production on bullock farms was 6345 MJ/ha. Growing mustard, wheat, potatoes and rabi fodder required 7700, 15941, 42824 and 32299 MJ/ha of total energy input respectively. (Surendra Singh *et al.*, 1995) [12]. According to Naravana *et al.*, (1998) [9], the country plough and straight blade hoe had the highest total energy requirement of 15341 MJ/ha for groundnut production in red soil, while the implement package with the lowest total energy requirement of 13230 MJ/ha included a mould board plough, a blade harrow, a mechanical seed drill, and a universal hoe. With all these factors in consideration, the current study was conducted to determine the energy efficiency of the conventional method of cultivation by farmers and mechanized method of groundnut cultivation in order to assist them to grow this cash crop more profitably.

Materials and Methods

The experiment was conducted at Regional Research Station, Virdhachalam, Tamil Nadu during the *kharif* season of 2023 to study the different sowing, weeding and harvesting methods of groundnut cultivation. The experiment was carried out in split-plot design replicated thrice. The main plot involves three methods of sowing *viz*., line sowing manually (M_1), hand push seeder (M_2) and multicrop seeder (M_3). The sub plot involves three methods of weed and harvesting operations *viz*., hand weeding twice at 25 DAS and at 45 DAS (S_1), weeding by nail weeder at 25 DAS and 45 DAS (S_2), weeding by power weeder at 25 and 45 DAS (S_3). The groundnut variety selected for the experiment was VRI 10 with duration of 95 days. A common dose of N, P_2O_5 and K_2O @ 25:50:75 kg/ha was used common in all treatments.

Land preparation is done by disc harrow followed by tractor drawn rotavator. Normal line sowing by labours is followed in M_1, seeds are sown in flatbed method by hand push seeder in M_2, and in multicrop seeder both furrow making process and sowing operation were done simultaneously in M_3. Observations were recorded for growth, weed and yield attributes. Energetics and economics of different treatments were worked out by considering the present market price of the inputs and outputs.

Energy ratio between output and input energy of the agricultural system gives the energy efficiency. Inputs like labours, machinery, diesel, fertilizers, pesticides and seed were used for input energy. Economical and biological yield of groundnut crop have been used to estimate the output energy. Energy equivalents shown in (Table 1) were used for estimation. Basic information of energy inputs and outputs were transferred to excel spreadsheet and analyzed. Based on the input and output energy equivalents energy use efficiency is calculated. Highest input-output ratio was identified as energy efficient implement package for groundnut production. The evaluation of energy use efficiency was calculated by the following formulae.

$$\text{Energy use efficiency} = \frac{\text{Energy output (MJ/ha)}}{\text{Energy input (MJ/ha)}}$$

Table 1: Energy equivalent of inputs and outputs in groundnut production

Particulars	Unit	Energy equivalent (MJ unit $^{-1}$)	References
A. Inputs			
1. Human labour			
a. Man	H	1.96	Power *et al.*, 2020 [14]
b. Women	H	1.75	Power *et al.*, 2020 [14]
1. Groundnut seed	Kg	25	Firouzi and Aminpanah, 2012 [11]
2. Fuel			
a. Diesel	L	56.31	(Rahman and Barmon 2015) [15]
b. Petroleum	L	46.3	
3. Fertilizers			
a. Nitrogen	Kg	60.6	Singh *et al.*, 2019 [19]
b. Phosphorus	Kg	11.1	Singh *et al.*, 2019 [19]
c. Potassium	Kg	6.7	Singh *et al.*, 2019 [19]
4. Chemicals			
a. Pesticides	Kg	199	Singh *et al.*, 2019 [19]
A. Output			
1. Groundnut pod yield	Kg	25	Firouzi and Aminpanah, 2012 [11]
2. Groundnut Haulm yield	Kg	12.5	

Table 2: Operation and source wise energy use (MJ/ha) among different treatments for groundnut cultivation.

Parameters	Treatments								
	M_1S_1	M_1S_2	M_1S_3	M_2S_1	M_2S_2	M_2S_3	M_3S_1	M_3S_2	M_3S_3
Field preparation	2377.84			2377.84			2377.84		
Fertilizer	2572.2			2572.2			2572.2		
Seeds	5000			5000			5000		
Others	617.92			617.92			617.92		
Sowing	301.44			78.4			225.24		
Weeding	840	250.88	155.31	840	250.88	155.31	840	250.88	155.31
Harvesting	420	263.1	263.1	420	263.1	263.1	420	263.1	263.1
Stripping	980	450.48	450.48	980	450.48	450.48	980	450.48	450.48
Total input energy	13109	11834	11738	12886	11611	11515	13033	11758	11662
Pod yield	2433	2329	2513	2689	2573	2756	2612	2461	2617
Haulm yield	5407	5245	5595	5969	5519	6333	5671	5326	5893
Output energy (MJ/ha)									
Pod	60817	58225	62817	67217	64317	68908	65308	61525	65433
Haulm	67587	65567	69931	74608	68985	79163	70892	66569	73657
Total output energy	128404	123792	132748	141825	133301	148071	136200	128094	139090
Energy ratio	9.79	10.46	11.31	11.01	11.48	12.86	10.45	10.89	11.93

Table 3: Input energy, output energy and energy use efficiency requirement among different treatments for groundnut cultivation.

Treatments	Input energy (MJ/ha)				Output energy (MJ/ha)				Energy use efficiency			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	13109	12886	13033	13009	128404	141825	136200	135476	9.79	11.01	10.45	10.42
S_2	11834	11611	11758	11734	123792	133301	128094	128396	10.46	11.48	10.89	10.94
S_3	11738	11515	11662	12127	132748	148071	139090	139970	11.31	12.86	11.54	11.90
Mean	12227	12004	12151		128315	141066	134461		10.52	11.78	11.09	

Main Plot (Crop Establishment)
M_1: Line sowing (conventional)
M_2: Hand push seeder
M_3: Multicrop seeder

Sub Plot (Weed management)
S_1: Hand weeding (HW) twice***** + Manual (harvest + stripping) (conventional)
S_2: Weeding through nail weeder***** + Mechanical harvest (digger + stripper)
S_3: Weeding through power weeder***** + Mechanical harvest (digger + stripper)
*@ 25 & 45 DAS

Table 4: Effect of different treatments on total input energy and yield of groundnut

Treatments	Total input energy (MJ/ha)	Pod Yield (Kg/ha)
M_1S_1	13109	2433
M_1S_2	11834	2329
M_1S_3	11738	2513
M_2S_1	12886	2689
M_2S_2	11611	2573
M_2S_3	11515	2756
M_3S_1	13033	2612
M_3S_2	11758	2461
M_3S_3	11662	2617

Results and Discussion

Groundnut pod yield

Mechanizing sowing, weeding and harvesting operations recorded significant variation on pod yield of groundnut. Sowing through hand push seeder recorded higher pod yield (2756 kg/ha) compared to other sowing methods followed by sowing though multicrop seeder (2617 kg/ha). Less pod yield (2329 kg/ha) was recorded under manual sowing. Among the weeding and harvesting methods, weeding through power weeder and mechanical harvest and stripping recorded higher pod yield (2756 kg/ha). Weeding through nail weeder and mechanical harvest and stripping recorded lesser pod yield (2329 kg/ha).

Energetics

The data on input energy, output energy and energy use efficiency are represented through graphical representation (Fig 1). Different sowing operations, weeding and harvesting operations showed significant variation. The energy spent for field preparation, fertilizers and others are common for all the treatments (Table 2). The energy supplied through seed in all the treatment was same 5000 MJ/ha as the uniform seed rate was maintained in all the treatments and energy spent for sowing, weeding, harvesting and stripping operations are different.

For sowing operation, the higher input energy of 301.44 MJ/ha was used in hand sowing followed by 225.24 MJ/ha for multicrop seeder and lower input energy of 78.4 MJ/ha was used in hand push seeder. With respect to weeding and harvesting, higher input energy of 2240 MJ/ha was consumed by hand weeding and manual harvest followed by 964.46 MJ/ha for nail weeder and mechanical harvest and lower input energy of 868.89 MJ/ha was consumed by power weeder and mechanical harvest (Table 2).

It was observed that the higher input energy of 13109 MJ/ha was consumed by conventional method of sowing, weeding, harvesting and stripping. The lower input energy of 11515 MJ/ha was consumed by groundnut mechanization package which involves hand push seeder, power weeder, mechanical harvester and stripper.

The higher output energy of 148071 MJ/ha is obtained from sowing with hand push seeder, weeding with power weeder and mechanical harvest. Lower output energy of 123792 MJ/ha is from sowing manually, weeding with nail weeder and mechanical harvest. The effect of different treatments on total input energy and yield of groundnut are given in Table 4.

The energy use efficiency (12.86) is higher under sowing through hand push seeder, weeding with power weeder and

mechanical harvest. Conventional method of manual sowing, weeding and manual harvest recorded less energy use efficiency (9.79). Mechanization has a prime role as a force multiplier to compensate labour shortage and for carrying out the operation in time resulting in higher productivity (Harisudan, 2012) [4].

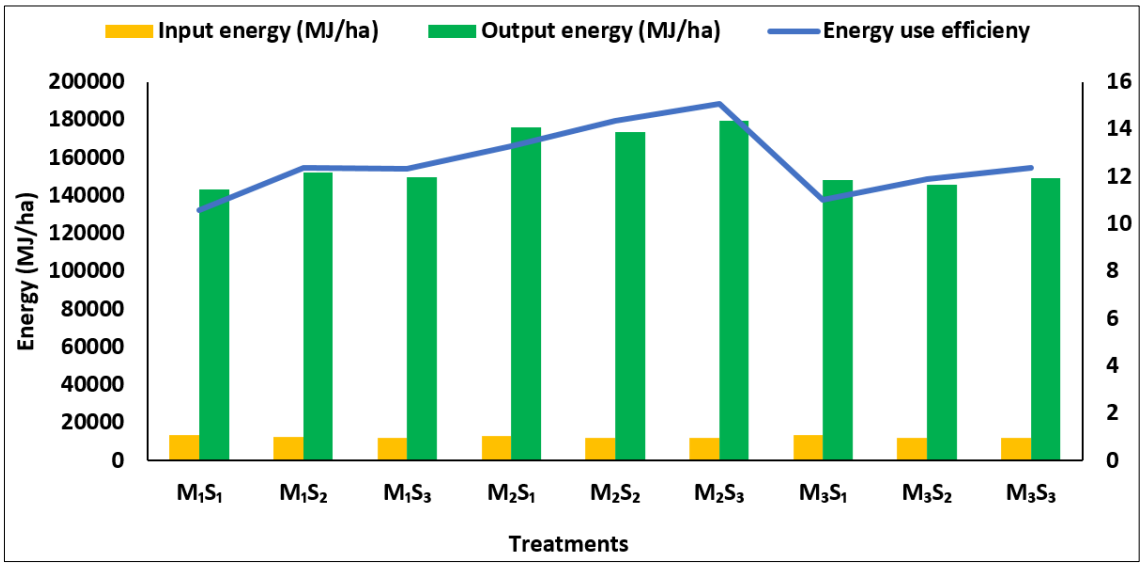

Fig 1: Input energy (MJ/ha), output energy (MJ/ha) and energy use efficiency of mechanized groundnut cultivations

Conclusion

The energy use pattern in various treatments of groundnut cultivation showed that among all the operations, conventional manual method of cultivation consumed higher amount of energy and lower energy use efficiency. Mechanized cultivation of sowing through hand push seeder, weeding through power weeder and harvesting through groundnut digger and stripper consumes less input energy and higher energy use efficiency which is very much useful to small and marginal groundnut farmers. Likewise, timely sowing, weeding and harvesting operation through machineries recorded higher pod yield compared to manual method.

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