Energy Consumption and Cost Analysis of Different Chickpea Nipping Operations

Abstract

India contributes 65% in chickpea production over top 10 chickpea growing countries. Chickpea is a *rabi* crop generally grown after rice. An interculture operation is formed four to six weeks after sowing of chickpea in which chickpea leaves were nipped to boost its growth that is known as nipping. Two to three time nipping needed in chickpea crop. That is important operation that helps for more production. In this study different four nipping methods are discussed *viz.* manual nipping/plucking (T1), manual harvesting with sickle (T2), battery operated leafy harvester (T3) and engine operated Manual push type engine operated leafy crop harvester (T4). It was observed that minimum energy consumed with battery operated leafy crop harvester and maximum was observed with petrol operated leafy crop harvester. Energy consumption of different nipping methods *viz.* manual nipping/plucking (T1), manual harvesting with sickle (T2), battery operated leafy harvester (T3) and engine operated Manual push type engine operated leafy crop harvester (T4) were found to be 392.00, 352.79, 191.15 and 839.33 MJ/ha respectively, where the cost of operation was calculated of about 20.09, 18.60, 20.82 and 3.88 ₹/ha, respectively. Petrol operated machinery was consuming more energy it revealed that non-renewable energy source consumed more energy as well as it affects our environment.

Keywords: energy calculation; mechanical nipping; nipping in chickpea; nipping methods.

1. Introduction

Chickpea was cultivated in 106 lakh ha in India at 2017-18. The country harvested a record production of more than 111 lakh tonne at the ever highest productivity level of 1056 kg/ha (Anon, 2019 a). India contributes 65% in chickpea production over top 10 chickpea growing countries (Merga and Haji, 2019). Chickpea producing states in India are Madhya Pradesh (29.37%), Maharashtra (20.03%), Andhra Pradesh (15.48%), Rajasthan (9.73%), Karnataka (9.63%), Uttar Pradesh (6.42%), Gujarat (3.57%) and Chhattisgarh in ninth position (Anonymous, 2011). In Chhattisgarh cultivation area, production and productivity of chickpea in 2010-2011 was 2.519 lakh ha, 2.415 lakh tonne and 891 kg/ha, respectively, where it was increased 3.18 lakh hectare, 3.20 lakh tonne and 1010 kg/ha, respectively in 2017-18 (Anon, 2019 b). The green leaf in early stage of the chickpea was also important for farmers of

Chhattisgarh as remunerative value. Green leaves harvested from chickpea are known as nipping. This was one of the key practices for the improvement of yield as well as yield contributing factors. It was also helpful to improve the number of branches, pods and growth rate of the chickpea crop (Singh and Diwakar, 1995).

It was reported that nipping practices show a significant effect on growth and yield of chickpea (Singh et al., 2020; Aziz, 2000, Kumar et al., 2017, Tripathi, 2019, Choudhary *et al.*, 2020). It was also conclude that nipping at last week of December to the end of January was reported to be best for improving yield and extra feed for cattle (Khan et al., 2006). An experiment was conducted during 2008-09 with chickpea variety NIFA-2005 to investigate the appropriate nipping technique as well as to sort out combination of spacing and nipping (Baloch *et al.*, 2010) and it was reported that the nipping was a profitable practice for chickpea growers that enhanced the yield and yield contributing parameters of that crop. Khan *et al.* (2017) analyzed the effect of nipping in chickpea. They conducted an experiment by using eleven *Desi* and nine *kabuli* total twenty chickpea genotypes with two treatments (nipped and control) and made nipping twice at 20-25 days of interval and observed that nipping was significantly affecting the crop characteristics in all genotypes. It was necessary to identify and develop a proper nipping technique to reduce its cost and energy involved in it. The study's objective was to determine feasible nipping methods for the development of mechanical nipping equipment as well as for cost reduction in nipping chickpeas.

2. Material and methods

Different nipping methods were selected to evaluate their performance based on nipping efficiency, field capacity, energy requirement and cost of operation at the Swami Vivekanand College of Agricultural Engineering and Research Station, IGKV, Raipur (C.G.), India. Manual plucking/nipping (Fig. 1) and manual harvesting with sickle (Fig. 2) were commonly used practice for nipping in chickpea. Battery operated leafy harvester (Fig. 3) and manual push type engine operated leafy crop harvester (Fig. 4) developed by IGKV, Raipur for nipping operation were also used in this study. Detailed specification of battery operated leafy harvester and manual push type engine operated leafy crop harvester is given in Table 1.

2.1 Experimental Design

A Randomised Block Design was used for the experimental study by taking four treatments with their five replications and performance was evaluated by considering different nipping parameters *viz.* nipping efficiency (%), field capacity (ha/h) and nipping capacity (tonne/h). Net plot size for the experiment was 50 m × 50 m, total numbers of plot was 20 and distance between two replications and plots were taken 0.5 m. These following nipping methods were considered as four treatments for the study:

T1 = Manual hand plucking;

T2 = Manual harvesting with sickle;

T3 = Battery operated leafy harvester; and

T4 = Manual push type engine operated leafy crop harvester.

Fig. 1: Manual hand plucking

Fig. 2: Manual harvesting with sickle

Fig. 3: Battery operated leafy harvester

Fig. 4: Manual push type engine operated leafy crop harvester

Table 1: Specification of battery operated leaf harvester

S.No.	Parameters	Values
1.	Length of blade	300 mm
2.	Machine net weight	2.1 kg
3.	Motor rated power	60 W
4.	Battery	Lead acid battery 24V DC 8AH
5.	Running time	3-5 h after full charge

Table 2: Specification of battery operated leaf harvester

S.No.	Parameters	Value
1.	Length ×Width × Height, mm	1500 × 800 × 1100
2.	Engine	1 hp (7600 rpm)
3.	Fuel	Petrol
5.	Frame	Stainless steel
6.	Cutting unit	Reciprocation cutter bar
7.	Blower	Centrifugal
8.	Conveyor belt	Canvas
9.	Storage Capacity, m^3	0.06
10.	Front wheel, diameter in mm	200
11.	Rear wheel, diameter in mm	600

2.2 Nipping efficiency

Total weight of crop obtained from the field was considered 100%, nipping efficiency was determined by subtracting header loss (%) and conveying loss (%) from the 100% as presented in Equation 1.

$$\text{Nipping ef iciency, \%} = 100 - \text{header loss (\%)} - \text{Conveying loss (\%)} \qquad \ldots (1)$$

Header loss was the remaining non harvested crop in field after passing of machine and determined by using Equation 2. Conveying loss was the harvested crop left in the field after machine operation. It was determined by using Equation 3.

$$\text{Header loss, \%} = \frac{\text{Weight of non harvested crop}}{\text{Totat weight of crop}} \times 100 \qquad \ldots (2)$$

$$\text{Conveying loss, \%} = \frac{\text{Weight of harvested crop left in the ield}}{\text{Totat weight of crop}} \times 100 \qquad \text{... (3)}$$

2.3 Field capacity

The actual covered area during operation was called actual or effective field capacity and it was calculated by using Equation 4 (Diwan et al., 2020). In this term we consider the useful time and time loss for turning the machine.

$$FC = \frac{A}{T} \qquad \text{... (4)}$$

Where,

FC = Field capacity, ha/h;

A = Area covered, ha; and

T = Productive time, h.

2.4 Cost of operation

Cost of operation depends on initial cost of implements, maintenance and labour cost. The machinery operational cost was divided into fixed and variable cost. Fixed cost was independent of operational use and cost of operation was increase/decreases with the variable cost (Kamboj *et al.* 2012). Standard methodology was used to calculate the cost of operation of the machine (Anon, 1976; Bainer *et al.*, 1956). Assumptions for the cost analysis were; salvage value (10% of initial cost), rate of interest (10% per annum), petrol cost (₹ 90/- per liter), lubrication cost (20% of fuel cost), repair and maintenance cost (5% of initial cost) and housing cost (2 % of initial cost) and labour charges (₹ 315/- per day). The initial cost of manual push type engine operated leafy crop harvester and battery operated leafy harvester was ₹ 43245/- and ₹ 10000/-. The expected life was annual use of manual push type engine operated leafy crop harvester was taken as 10 year and 250 h/year, respectively and for battery operated leafy harvester it was 5 year and 150 h/year, respectively.

2.5 Energy analysis

Mainly three types of energy were involved in weeding operations which were mechanical energy, human energy and chemical energy. Energy equivalents of different souces *viz.* human energy, petrol energy, electricity, implement and self-propelled machine energy were taken 1.96 MJ/h, 48.23 MJ/l, 11.93 MJ/kWh, 62.70 MJ/kg and 68.40 MJ/kg respectively (Nassiri and Singh, 2008; Lal *et al.*, 2016, Saad *et al.*, 2016; Singh and Chandra, 2001). A specific mathematical model for calculating energy balance was used as given below. Following formula was used to determining the energy input during weeding operation (Singh and Mettal, 1992).

$$\text{Energy input} = \text{Human energy} + \text{Fuel energy} + \text{Machine energy} \qquad \ldots (5)$$

Where,

$$\text{Human energy} = \text{Useful man hour (h/ha)} \times \text{Energy equivalent (MJ/h)}$$

$$\text{Fuel energy} = \text{fuel consumption (l/ha)} \times \text{energy equivalent (MJ/ha)}$$

$$\text{Electricity energy} = \text{Electricity consumed (kWh/ha)} \times \text{energy equivalent (MJ/kWh)}$$

$$\text{Machine energy} = \frac{\text{weight of the machine(kg)} \times \text{energy equivalent(MJ/kg)} \times \text{useful working hour (h/ha)}}{\text{Total life of machine(h)}}$$

$$\text{Energy Cost} = \frac{\text{Cost of operaion, (₹/ha)}}{\text{Energy (MJ/ha)}} \qquad \ldots (6)$$

3. Result and Discussions

Nipping efficiency, field capacity, nipping capacity, energy requirement, cost of operation and energy cost of different nipping methods depicted in Table 3. The nipping efficiency, field capacity and nipping capacity of different treatments were observed significant difference at 5% level with CD value of 1.251, 0.002 and 0.012, respectively. The nipping efficiency was observed maximum in manual Nipping method of about 99.21% followed by T2, T4 and T3. Field capacity and nipping capacity was found maximum in manual push type engine operated leafy crop harvester (T4) of about 0.051 ha/h and 0.127 tonne/h respectively. Energy requirement was found minimum in battery operated leafy harvester (T3) of about 191.15 MJ/ha and highest energy requirement was observed with T4 of about 839.33 MJ/ha, But the energy cost was found minimum in T4 of about 3.88 ₹/MJ.

Cost of the operation of the manual push type engine operated leafy crop harvester was found to be ₹ 3259.31/- per hectare. It was observed that the developed prototype is more economical as compared to the others methods widely used in Chhattisgarh. The cost of leafy crop nipping by manual hand harvesting (T1), harvesting with sickle (T2) and harvesting with battery operated harvester (T3) 141.62%, 101.35% and 22.133%, respectively were found higher than the developed leafy crop harvester (T4). Energy consumption was found minimum in battery operated leafy harvester (T3) of about 191.15 MJ/ha and maximum in manual push type engine operated leafy crop harvester (T4) of about 839.33 MJ/ha it was much higher than the other selected methods. As shown in Fig 1 the energy in treatment T4, more energy consumed by fuel energy (771.68 MJ/ha) that belongs to non-renewable energy sources.

Table 3: Performance of various nipping methods

Nipping Methods	Nipping efficiency, %	Field capacity, ha/h	Nipping capacity, tonne/h	Energy requirement, MJ/ha	Cost of operation, ₹/MJ	Energy cost, ₹/MJ
Manual hand plucking (T1)	99.21	0.005	0.013	392.00	7875.00	20.09
Manual harvesting with sickle (T2)	98.34	0.006	0.016	352.79	6562.50	18.60
Battery operated leafy harvester (T3)	92.82	0.015	0.036	191.15	3980.56	20.82
Manual push type engine operated leafy crop harvester (T4)	96.82	0.051	0.127	839.33	3259.31	3.88
C.D.	1.251	0.002	0.012	-	-	-
SE(m) ±	0.402	0.001	0.004	-	-	-

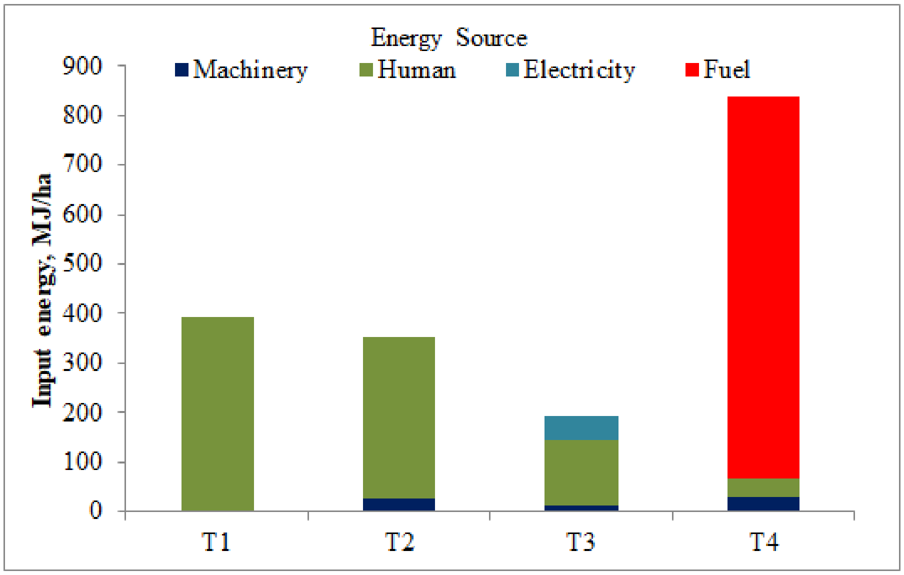

Figure 5:

Figure 5: Energy consumption for non-renewable energy sources

renewable energy sources

4. Conclusion

The nipping efficiency was observed highest with manual hand plucking but field capacity and nipping capacity was observed highest in manual push type engine operated leafy crop harvester. It was concluded that the utilization of machinery effectively reduces the cost of operation. Cost of operation of different nipping methods *viz.* manual hand plucking (T1), manual harvesting with sickle (T2) and battery operated leafy harvester (T3) were found 141.62%, 101.35% and 22.13% more over the manual push type engine operated leafy crop harvester (T4). The manual push type engine operated leafy crop harvester may be modified for the battery operated engines to reduce the energy consumption. By avoiding the non-renewable source like petrol we can reduce their adverse effect on our environment.

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