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Studies on comparative efficiency of different mechanical harvesters in coffee with reference to manual harvesting

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Mechanization is relatively new and coffee still remains primarily as a hand crop. The coffee cultivation in countries like Brazil, USA (Hawaii) and Australia has been mechanized to a great extent to bring down dependence on human labour, which is very expensive in these countries. In countries including India, coffee is essentially grown in hilly and undulating terrain coupled with presence of shade trees and the operations are carried out mainly by human labour making mechanization in coffee virtually impossible.

Among the plantation crops, coffee is one of the most labour intensive crop after tea in India. The annual requirement of labour for undertaking regular cultural operations is about 456 per ha in case of Arabica, 266 per ha in case of unirrigated Robusta and 326 per ha in case of irrigated Robusta coffee. The cost of labour alone constitutes about 70 per cent of the total cultivation costs in case of Arabica and about 59 to 65 per cent in case of Robusta coffee.

In recent years, labour shortage in plantation sector has become acute due to migration of workers to urban areas in search of easy and better living. Majority of the permanent workers employed in the farms belong to older age group aggravating the labour shortage for critical operations. Due to the uneven slopy terrain and presence of shade trees, use of big machinery is ruled out in coffee estates. Thus, efforts were being made at Central Coffee Research Institute to design small size machineries suitable for use in sloping terrains of coffee estates. In this direction, the Institute has been evaluating various machineries available in the market to study their suitability in coffee estates.

Among the total labour requirement, about one-third of the labour is required only for harvesting and processing of coffee at estate level. The harvesting period being short (November to March), there is a lot of pressure on the availability of workers since the operation is spread over all the estates in different zones. Thus, harvesting is one of the most preferred operations for introducing mechanization in coffee.

In recent years, especially after the year 2000, though prices were good for coffee, the planter was unable to carry out all the operations in their holdings due to acute scarcity of labour coupled with high wages demanded by the contractors. In view of this, it is essential to think over the alternate methods to carryout the cultural operations. Thus, there is a need to improve the efficiency of input use and increase the productivity of labour and the land to reduce the cost of production and to increase overall income from the holdings. One such advent could be introduction of mechanization to carry out field operations (Raghuramulu, 2009). Harvesting operations in coffee is time bound where the berries are harvested in time, to avoid berry drop. For timely harvesting and to reduce the risk of the labour availability, a research work was initiated with the objectives of studying the efficacy of two types of

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harvesting machines, their suitability in harvesting different varieties and the efficacy of mechanical verses manual harvesting.

The study was conducted during 2009-10 harvesting season to evaluate the efficiency of two types of hand held battery operated harvesting machines/mechanical shakers *viz.,* indigenous harvester (Coffee bean stripper) and imported harvester (Guliver) in Arabica coffee at CCRI farm and Robusta coffee in private estates and compared with manual harvesting. Mechanical shaker or harvesting equipment consists of shaker, catching frame and conveying devices (Fig. 1 and 2). The basic principle is to accelerate each fruit so that inertia force developed will be greater than the bonding force between the fruit and the tree (Kepner *et al*., 1987, Duncan *et al.*, 2008). The number of coffee berries detached depends on the exposure to mechanical vibration, which in turn is determined by the amplitude and frequency of the shaking of the catching frames, the height from the ground at which the tree is shaken, the height of the tree, the strength of bond between the berries and the tree, the duration of exposure to shaking and the mass of the berries.

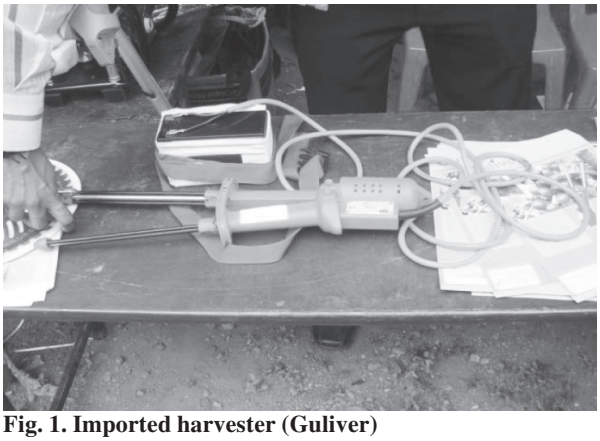

Fig. 1. Imported harvester (Guliver)

Fig. 2. Indigenous harvester (Coffee bean stripper)

The harvesters were provided with an electronic card which controlled frequency stabilization, short-circuit protection, overload restriction. It was supplied with 3.2 m long cable, belt and 12V rechargeable battery for operating 8 hours and weighed around 900 g. Data on number of plants harvested per day, time taken to harvest, quantity of fruits harvested, fallen green leaves, number of bearing wood removed and damaged fruits were recorded. The data was worked out for both manual and mechanical harvesters for a working day of 6 hours. Two workers were employed for each mechanical harvesting machine *i.e.,* for harvesting and for spreading the mat and collection of fruits. An equal number of workers were used for manual harvesting of fruits which served as control.

Evaluation of mechanical harvesters in Arabica coffee plantation

In case of Arabica coffee, the data revealed that fruit harvested per man day differed with different mechanical harvesters and manual harvesting (Table 1). Indigenous and imported harvesters harvested 86.6 kg and 83.9 kg fruit per man day respectively, while 73.7 kg fruit per man day was harvested manually by (Table 1). There was not much difference among the two types of the mechanical harvesters in terms of quantity of fruits harvested per man day. The quantity of fruit harvested was more (12 kg fruits per man day) in mechanical harvesters compared to manual harvesting. In terms of harvesting efficiency, it was not comparable with manual, as it was only about 14 to 18 per cent higher output efficiency over manual harvesting.

The mechanical harvesting resulted in 13.1 to 13.9 per cent damage to fruits compared to manual which was only 3.5 per cent. Besides, mechanical harvesting also resulted in damaging of 1.2 to 1.6 productive twigs per man day, while it was almost nil (0.1 per cent) in case of manual harvesting. Productive twigs are the twigs which carries berries of the successive year, if lost leads to adequate loss

Table 1. Comparison of mechanical harvesting *vs* manual harvesting in Arabica coffee

Mode of harvesting	No. of Labour	Total number of plants harvested day^{-1}	Total fruit harvested (kg) man day^{-1}	Per cent increase over manual	Productive twigs damaged/ plant (No.)	Damaged fruits (%)
Imported harvester	1	27	83.9	13.9	1.6	13.9
Indigenous harvester	1	43	86.7	17.6	1.2	13.2
Manual harvesting (Stripping)	1	39	73.7	-	0.1	3.5
SEm±		1.3	2.2	-	0.0	0.4
CD (5%)		3.9	6.7	-	0.1	1.1

of crop yield in the following year. Hence, the mechanical harvesters were not superior to manual harvesting in case of Arabica. Result obtained in the present study was in accordance to the findings of Venkatesha *et al*. (2010).

Evaluation of mechanical harvesters in Robusta coffee plantation

In Robusta, the quantity of fruit harvested by the mechanical harvesters *i.e*., coffee bean stripper was 137 kg per man day, which was significantly more by 37 kg per man day when compared to manual harvesting (100 kg fruits per man day). The damage occurred to the fruits while harvesting on use of mechanical harvesters was more in Arabica coffee (13.2 to 13.9 per cent) as against only 6.6 per cent in Robusta coffee, which was almost comparable with manual harvesting which recorded only 2.7 per cent in Robusta coffee (Table 2) .

There was no comparable difference in damage to productive branches among mechanical (1.5%) and manual harvesting (2.2%) methods implying that there was no significant crop loss on use of mechanical harvesters in Robusta coffee either in present year or successive year. In Arabica coffee, per cent damage of productive branches and damage to fruits was more as compared to Robusta. While, using mechanical harvester 16.7 per cent of labour and cost was saved over manual in case of Arabica and 35.8 per cent in case of Robusta (Table 3). These results indicate that there is a good scope for harnessing mechanical harvesting in case of Robusta coffee under Indian conditions compared to Arabica coffee. Similar findings were reported by Venkatesha *et al*. (2010).

Table 2. Comparison of mechanical harvester *vs* manual harvesting in Robusta coffee

Mode of harvesting	No. of Labour	Total number of plants harvested day^{-1}	Total fruit harvested (kg) man day^{-1}	Per cent increase over manual harvesting	Productive twigs damaged/ plant (No.)	Damaged fruits (%)
Indigenous harvester	1	25	137.0	37.0	1.5	6.6
Manual harvesting (Stripping)	1	18	100.9	-	2.2	2.7
SEm±		0.8	1.8		0.1	0.2
CD (5%)		2.5	5.5		0.3	0.5

Table 3. Economic analysis of mechanical harvester *vs* manual harvesting in Arabica and Robusta coffee

Mode of harvesting	Number of labour required for harvesting ha^{-1}		Labour cost (₹ ha^{-1})		Per cent labour and cost saving over manual	
	Arabica	Robusta	Arabica	Robusta	Arabica	Robusta
Indigenous harvester	72	53	10800	7950	16.7	35.8
Manual harvesting (Stripping)	84	72	12600	10800	-	-

From the study, it can be concluded that use of mechanical harvesters offers a good scope in Robusta coffee than Arabica coffee under Indian conditions to avoid the drudgery and dependence of labour and to improve the efficiency of the farm workers. However, it is optional to use the mechanical harvester in Arabica.

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