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Assessment of mango harvester for drudgery reduction over conventional methods

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Abstract
In the harvesting of different fruits two major methods were followed by Indian farmers that are manual plucking and tree shaking. The tree branches are shaken to speed up the harvesting, which results in post harvest losses due to the physical damage, stem end rot and sap bleeding in mangoes due to absence of pedicel. To overcome these local harvesting methods and to reduce the drudgery of the farmers Bihar Agricultural University, Sabour has developed five types of mango harvesters (Model A,B,C,D and E). Three harvesters (Model C,D and E) are manual operated and works on the principal of pulling/cutting, while one is power operated (Model B) which works on battery for power, and uses cutting principal, and another one (Model A) is manual-cum-power (battery) operated which uses cutting as well as pulling action for detachment of mangoes from tree branches.
The local harvester harvests fruit without pedicel, whereas developed models, an improvement on the conventional harvester harvests the fruit with pedicel. The fruit harvest per hour was more in Model C (manual operated) that was (80-88 fruits/ 10 min) when compared to local harvester, manual plucking and tree shaking The number of labours per day for fruit harvesting was more in manual plucking and tree shaking, where as in developed harvester (Model C) took less labours that is (18 labours/day). Among harvesters Model C has higher efficiency over local model in labour and time saving. Model C has advantages over all the models A, B, D and E in terms of number of mangoes plucked, damages, and labour requirement.

Keywords: Conventional harvester, Drudgery, Harvesters, Labours, Local harvester, Mango harvester, Pedicel

Introduction
Mango (*Mangifera indica* L.) belongs to family *Anacardiaceae*. It is called “the king of fruits” on account of its nutritive value, taste, attractive fragrance and health promoting qualities (Gowda, 1995) [1]. It is commercially cultivated in more than 80 countries including Brazil, China, Egypt, India, Indonesia, Mexico, Pakistan, Phillipines, Thailand and Vietnam among these countries India is ranks number one in mango production. In India, the major mango growing states are Karnataka, Bihar, Gujarat, Tamil Nadu, Andhra Pradesh and Uttar Pradesh, and it occupied about 46 per cent of the global area and 40 per cent of the global production4. Mango is cultivated over an area of 25 lakh hectares with an annual production of 180.02 lakh metric tons in India during 2012-13.
India produces around 40 million tones of fruits per year. Timely harvesting of fruits is important for maintaining quality and shelf life. Harvesting of fruit trees is a cumbersome and time-consuming process. Different methods are being practiced. The Totapuri variety of mango is being harvested by shaking the tree manually and by plucking the fruits manually by

climbing the tree. The fruits are allowed to fall on the ground and then picked up. This causes internal injury to the fruits and subsequent spoilage during ripening. The fruit is held between frame and the pole and get detached while pulling the harvester1. The fruits harvested without pedicel oozes out the sap from the pedicel end, thereby reducing the shine of fruit, making it susceptible to the diseases like stem end rot.

The local mango harvester generally consists of a bamboo pole fixed with a small wooden piece at an angle to make „v" shape at the end. The fruits are harvested by cutting the pedicel and dropped on the ground. In conventional harvesting the labourers climb the tree to harvest and throw the fruits on a gunny bag held by a person on the ground to reduce the injury to the fruit. This is a time consuming process and sometimes can be dangerous to the labour. The fruit harvesters have been modified to increase the harvesting capacity of the person and reducing damage to the fruits. The harvesting capacity depends upon the plant height, yield and type of fruit (Prabhakar, 2006) [3].

The harvesting of horticultural crops is quite difficult due to their tallness. There are small hand tools available for harvesting. But these tools of harvesting and pruning are restricted due tree height, unavailability of trained labours for climbing and cost of operation etc. The mechanized machines are available; these are heavy and costly and are not suitable for low land holding, Indian marginal famers. Harvesting of mango with the available hand tool is very difficult. The labor has to climb on the tree by carrying these hand tools, which requires skill too. The manual harvesting is time consuming and tedious. To overcome with such difficulties, various manual/power operated mango harvesters have been developed for harvesting mangoes by BAU. These mango harvester harvests mango with 1-2 cm long pedicle, it needs less force to harvest the fruit and shelf life of the fruit is increased by 3-4 days. The fruits can be easily harvested from a height of 10-15ft, using these harvesters. The harvesters will increase the efficiency of the labour and reduce the harvesting time.

Material and Method

Five different models of mango harvesters were developed at Bihar Agricultural University, Sabour. Out of these five, three were manual operated, one was battery operated, while one was of Manual-cum-battery operated type. Details of all these mango harvesters are as below:

Table 1: Details of all these mango harvesters are as below

Model No.	Specification	Figure	Type
A	• Total length of aluminium rod = 12' • Perimeter of upper section: 74 cm • Dia along vertical axis: 30 cm • Dia along horizontal axis: 23 cm • Dia of blade = 12 cm • Battery power = 12 V • Cutting method: by pulling and blade revolution • Weight: 2.12 kg		Manual-cum-power operated
B	• Total length of steel rod = 6'+6'=12' • Perimeter of upper section: 74 cm • Dia along vertical axis: 30 cm • Dia along horizontal axis: 23 cm • Dia of blade = 12 cm • Battery power = 12 V • Cutting method: by blade revolution • Weight: 3.9 kg		Battery operated

C	• Total length of aluminium rod = 6.5'+ 6.5'=13' • Perimeter of upper section: 74 cm • Dia along vertical axis: 28 cm • Dia along horizontal axis: 20 cm • Opening for mango= 2.5 cm • Length of spring= 12 cm • Length of support = 17 cm • Cutting method: by pulling the rope and blade cutting • Weight: 1.6 kg		Manual operated
D	• Total length of aluminium rod = 6.5'+ 6.5'=13' • Perimeter of upper section: 78 cm • Dia along vertical axis: 29 cm • Dia along horizontal axis: 20 cm • Opening for mango= 1.5 cm • Cutting method: by pulling • Weight: 1.5 kg		Manual operated
E	• Total length of aluminium rod = 6.5'+ 6.5'=13' • Perimeter of upper section: 78 cm • Dia along vertical axis: 33 cm • Dia along horizontal axis: 22 cm • Opening for mango= 2.5 cm + 2.5 cm • Length of divider = 11 cm • Cutting method: by pulling • Weight: 1.5 kg		

Results and discussion

The trials were carried out at 7 trails in different places of Bhagalpur District. The plant heights ranged from 15-30 feet height. Area of mango orchard ranged from 1.0-5.0 Hectare. The results of different methods of harvesting are presented in Table 1. The fruit harvest per 10 minute time was more in Model C that was (80-88 fruits/10 min) in comparison to all the models A, B, C and D. The mango harvester models A, B, C and D had plucked the mangoes in 10 minutes as 48-53, 38-42, 71-81 and 55-61 mangoes per 10 minute of time. When compared to local harvester, manual plucking and tree shaking these results are in line with results reported by Savita *et al*. (2010) [5]. The fruit damage was observed more in tree shaking method followed by manual plucking and use of local harvesters. The results are in line with the results reported by Mandhar and Senthil (1993) [2].

The beneficiaries of this study expressed that manual plucking and tree shaking methods were labour intensive process, time consuming with more per cent of damaged fruits and had high chances of breakage of the branches. The number of labours per day for fruit harvesting was more in manual plucking and tree shaking, where as in the case of Model C, harvester took less labours that is (18 labours/day). These results were in line with the study conducted by Savita *et al.*, (2010) [5]. The local model harvested fruits without pedicel resulting in oozing out of sap thereby reducing the shelf life and had a high percent of damage to fruits as they were dropped to the ground, whereas Model C was observed to be slightly heavy and found harvest plants with higher height, but harvested fruits with pedicel thereby increasing the shelf life of the fruit. Model C is comparatively highly suitable for harvesting the fruits for export. Number of mangoes plucked by different mango harvesters in 10 minute, Number of damaged Mangoes plucked in 10 Minute, and Harvesting capacity and Damage % of developed machines are shown in Table 1, 2 and 3 respectively. The cost and economics of use of harvester over other conventional methods of harvesting for one hectare per day is presented in Table 4. The highest amount saved was in Model C as compared to local harvester, tree shaking and hand plucking. Thus use of harvesters helps to save some economy as well as time by reducing the number of labour required to harvest one hectare.

Table 1: Number of mangoes plucked by different mango harvesters in 10 minute.

S. No. of Farmer	Model A	Model B	Model C	Model D	Model E
1	48	42	88	75	55
2	53	42	80	79	61
3	49	38	83	81	59
4	50	39	82	76	57
5	52	38	85	76	61
6	47	42	86	75	59
7	51	40	85	71	55

Table 2: Number of damaged Mangoes plucked in 10 Minute

S. No. of Farmer	Model A	Model B	Model C	Model D	Model E
1	4	6	1	2	5
2	5	7	3	3	4
3	4	4	0	1	5
4	3	5	4	3	2
5	5	5	2	1	4
6	4	6	3	2	5
7	3	3	1	2	3

Table 3: Harvesting capacity and Damage % of developed machines

Model Nos.	Time (Min)	Av. Nos. of Mangoes plucked	Av. Nos. of Damaged Mangoes	Damage %
A	10	50	4	8.0
B	10	40	5.14	13.0
C	10	84	2	2.4
D	10	76	2	2.6
E	10	58	4	6.9

Table 4: Economic analysis of different methods of mango harvesting of one hectare/day

Method of harvesting	Cost of Harvester (Rs.)	No. of labour / day	Amount required / day (Rs.)	Amount saved compared to hand plucking (Rs.)
Manual plucking	-	32	4800	-
Tree shaking	-	28	4200	600
Local harvester	-	25	3750	1050
Model C	1500	18	2700	2100

Conclusion

It could be concluded that the mango harvester can be used for harvesting mango fruits with less drudgery & fatigue on labour and also preventing damage to the tree branches as well as fruits as compared to local harvester, manual plucking and tree shaking. Among harvesters Model C has higher efficiency over local model, and all other developed models of BAU like Modal A, B, D and E. The pickers are expected to provide mango farmers higher income due to increase in quality and marketability of fruits. They can also serve as instructional tools in postharvest courses in state universities and colleges, as well as in extension activities on mango harvesting technology for local government units.

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