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Development of Manually Operated Citrus Fruit Harvester

H. D. Nahate*, V. G. Kothalkar and N. D. Patil

CAET, Jalgaon Jamod, India

**Corresponding author*

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A B S T R A C T

India is one of the largest producers of citrus in the world. Among the various operations followed by the producers while cultivation of orange, harvesting is the most critical in terms of possible damage to the fruits and musculoskeletal stress on the worker. This research work was carried out to develop the ergonomically feasible manual orange fruit harvesting system. The developed system consists of the aluminum tripod adjustable as per the operator's height and the whole harvester assembly mounted on the tripod. The performance of the improved system evaluated in terms of fruit selection, harvest rate, fruit damage and field performance by field tests and compared with traditional harvesting methods. The maximum harvest rate ranged from 49.26 to 64.12 kg/h and 37.12 to 45.70 kg/h for the harvesting of orange fruits by the traditional and improved method, respectively. The average damage to fruits in traditional method observed 14 percent and it was almost no fruit damage in improved method. The improved harvesting system found better than traditional methods and reduces musculoskeletal stress on the operator.

Introduction

India is the 4th largest producer of citrus in the world (NBH, 2015) with total production of 11.65 Million tonnes. In India, citrus ranks second in the area, sharing 15 percent of the total area under fruit crops. Citrus is of high importance in the horticultural industry now a days and a substantial source of income for the producers. Under citrus group, mandarins are the important, occupying 30 percent of the total area under citrus followed by limes (NBH, 2015). Among the various operations followed by the producers while cultivation of orange, harvesting is the most critical in terms of cost of operation and possible damage to the fruits.

Harvesting of orange is labor intensive operation and may involve 35-45 % of total production cost (Sanders, 2005). Most of the Indian farmers still practicing conventional hand-picking methods for harvesting. However, conventional methods are inefficient and more importantly results in deterioration of fruit quality and fruit damage. It is also seen that Hand-picking of fruits poses a risk on both the quality of harvested fruits and disorders of the musculoskeletal system of workers during the harvest (Mlotek, 2015).

A high stress on the human motoric system is observed when the picker is holding a

container of fruit (basket, bucket) with one hand and picking fruit with the other hand (Mlotek, 2015). Moreover, considerable neck pain has been reported during harvesting of fruits situated at the upper periphery of the tree. Therefore, the worker cannot harvest continuously (Mlotek, 2015).

Materials and Methods

Design of harvester

The dimensions of citrus fruits harvester will be selected based on the physical properties of citrus fruits, i.e., fruit dimensions. Citrus tree characteristics, i.e., Plant height, tree canopy, etc. Anthropometric characteristics of farm workers, i.e., grip diameter, shoulder grip length, grip span, height of workers. To decide the grip of handle following dimensions should be selected from the anthropometric database of farm workers

Fabrication of system components

Extension pipe

It is long hollow stainless steel pipe fitted on a tripod. Extension pipe should have an adjustable length to have easy reach to the fruit. The one locking mechanisms would be provided to extend or shorten pipe as per requirement. The overall length of extension pipe is 2119 mm respectively.

Cutting mechanism

The Falcon pruning secateurs used as a cutting mechanism. It is fitted on one of the ends of the extension pipe. It consists of scissor having one of the blades being fixed and other would be move to have a cut on the peduncle of fruit. The fruit-guider should be provided to guide the fruit within cutting zone. Hence, the cutting efficiency of the cutter increased.

Fruit collection bag

Fruit collection bag fitted at the end of extension pipe in such way that the fruit cut by cutting mechanism will fall in the bag. The maximum capacity of fruit collecting bag would be decided based on the ability of extension pipe to sustain the load of a bag filled with fruits with minimum possible bending. The capacity of the bag is 3-4 kg respectively.

Adjustable pipe

The supporting pipe made up of stainless steel material mounted on the tripod. The diameter of supporting pipe would keep slightly greater than the extension pipe for free movement. The purpose of supporting pipe would be for support as well as to prevent the extension pipe from bending. The length of adjustable pipe is 2438 mm respectively.

Handle/Clutch

The handle is provided to operate the cutting mechanism. It consists of steel cable having one end is connected to the cutting mechanism, and another end connected to the free end of extension pipe. The cutting mechanism operated by pulling cable in a downward direction when the fruit is in cutting zone. Cable takes its original position due to the action of spring fitted on the cutting mechanism.

Supporting assembly

The supporting assembly consists of trust bearing for 360° rotation of beam, provision for locking of extension pipe to a suitable position, provision for display mounting.

Telescopic tripod

This arrangement is optional. The whole harvesting assembly mounted on the

telescopic tripod. It is rigid enough to sustain a load of all parts of harvester without any deformation. The height of telescopic tripod can adjust according to the requirement.

Operation of harvester

The harvester to be developed to cut orange fruits pedicle by using scissor action as show in plate 2. The harvester components assembled and checked for any loose parts if any they tightened immediately. The harvester would be placed on fairly leveled ground between groups of four trees (spacing not more than 5×5 m) in such way that it has access to all of them.

In operation, the operator would hold the cable in one hand and another hand holds free end of extension pipe. As soon as fruit comes in cutting zone of the cutting mechanism, cutting mechanism operated by pulling cable in a downward direction. The fruit cut by cutting mechanisms fallen into collection bag provided just below it.

Results and Discussion

Parameters affecting harvesting efficiency

The output capacity or harvesting efficiency of fruit was mostly affected by the number of fruits present on the tree. Harvest rate obtained during prototype trial presented in table 1

Fruit damage rate

Fruit damage during harvesting is the key point for the evaluation of harvesting system table 2 indicates the fruit damage during harvesting by traditional and improved harvesting system. It indicated that traditional method involves more amount fruit damage compared to an improved method which has no fruit damage. Fruit damage leads to infection of various fruit diseases and sometimes much losses like dehydration as well more amount of respiration changes causes inefficiency for selection purpose which affects cost of given fruit. Fruit damge rate affects mostly to deterioration losses and hence grading affects to reduce the cost of given commodity. By proper selection of mature fruits amd proper size selection leads to better harvesting of fruits by manually operated citrus fruits harvester.

Harvest rate

The maximum harvest rate ranging from 49.26 to 64.12 kg/h and 52.70 to 54.09 kg/h for harvesting of citrus fruits by traditional and improved technique respectively. The harvest rate is more in traditional method compared to the improved method because of hand picking and sticks striking methods used for harvesting as show in table 2

Field performance

The field performance of the improved method and traditional method was evaluated in the different field by selecting group five adjacent trees randomly. The field performance was evaluated in terms of three parameters vise number of position per tree, number of fruit detached per position and time required for shifting per position. These parameters were evaluated and compared between traditional and improved method (table.3)

The number of position per tree

The maximum numbers of positions per tree in the traditional method were seven and in improved method were three, because the improved method has better reach than traditional method hence requires fewer shiftings.

Table.1 Anthropometric characteristics of farm workers for horticultural orchard

Parameter	Observations					Avg.
	R_1	R_2	R_3	R_4	R_5	
Grip diameter (inside) (mm)	45.7	59.80	56.32	62.69	47.52	**54.35**
Shoulder grip length (mm)	524.1	752.5	687.4	653.2	566.0	**663.64**
Grip Span (mm)	279.0	116.8	789.5	645.3	458.7	**457.86**
Worker Height(mm)	1570	1550	1620	1680	1720	**1628**

Table.2 Harvest rate of traditional and improved harvesting system

Shift No.	Harvest rate, kg/h	
	Traditional harvesting method	Improved harvesting system
1	62.21	41.20
2	49.26	55.12
3	53.84	58.65
4	50.23	44.37
5	58.14	42.94
6	52.18	52.79
7	62.89	57.26
8	63.66	45.70
9	56.30	44.92
10	64.12	50.85
Avg.	**57.28**	**54.09**

Table.3 Comparison of various performance parameter between traditional and improved harvesting system

Tree No.	Traditional harvesting method			Improved harvesting method		
	No. of position per tree	No. of fruit detached per position	Time required for shifting per position	No.of position per tree	No. of fruit detached per position	Time required for shifting per position
T_1	5	30	1.6	3	95	2.0
T_2	6	25	1.4	4	103	3. 1
T_3	5	35	1.5	2	85	3.2
T_4	7	38	1.6	3	110	3.4
T_5	6	30	1.5	2	105	3.3
Avg.	**5.80**	**31.91**	**1.52**	**3.20**	**99.60**	**3.00**

Fig.1 Schematic view of citrus fruits harvester

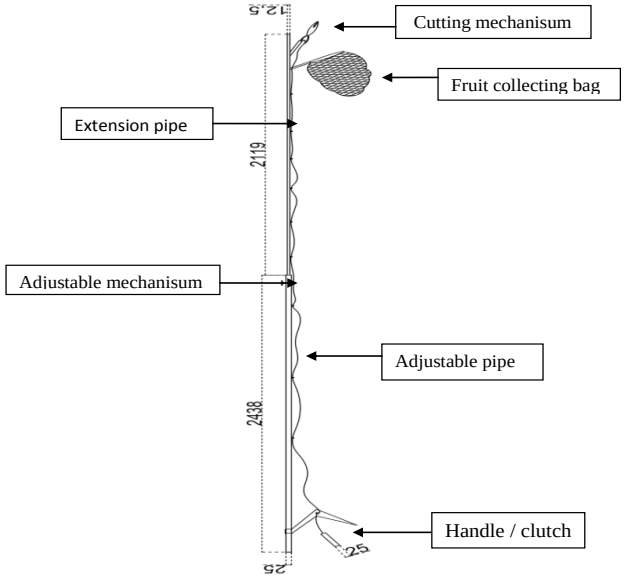
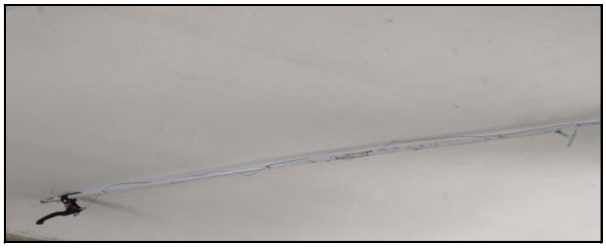


Plate.1 Various components of citrus fruit harvester

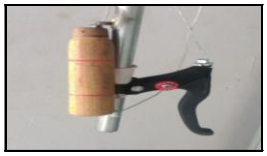


a) Extension pipe & adjustable pipe

b) Cutting mechanisum

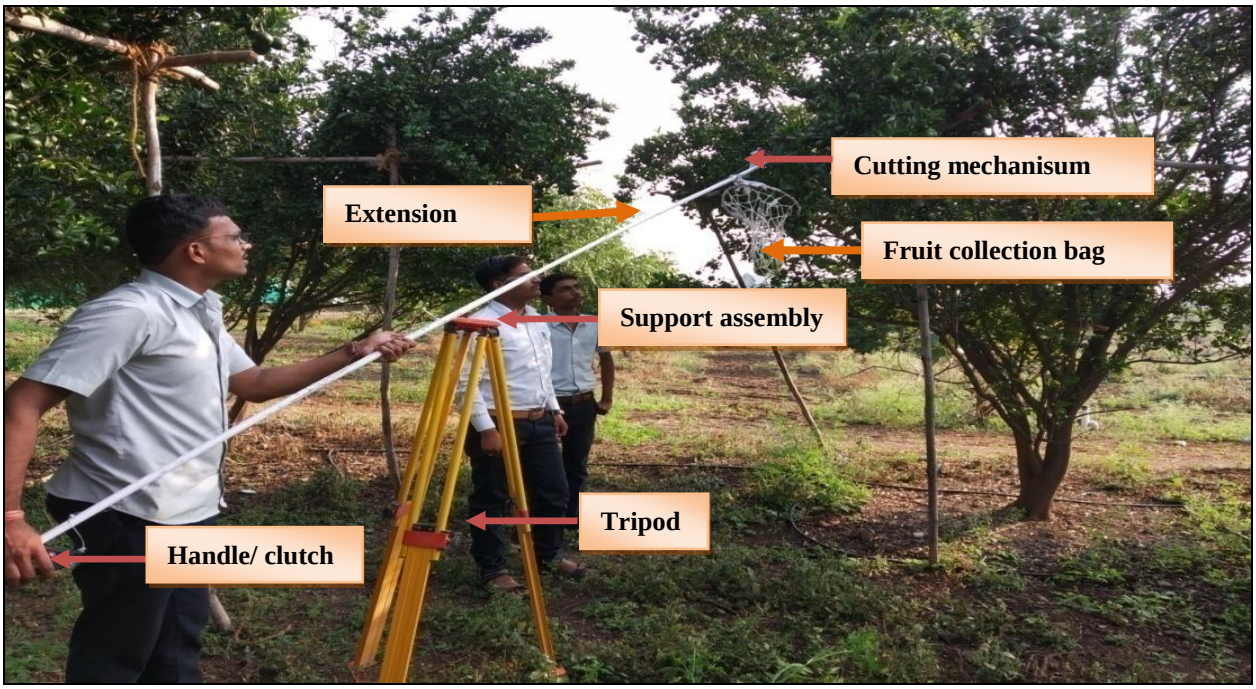
c) Fruit collection bag

d) Adjustable mechanisum



e) Handle / clutch

Plate.2 Trial taken during field performance



Time required cutting the citrus fruits

The time required for cutting the citrus fruits with developed machine was measured using the stopwatch.

The number of fruit detached per position

In the traditional method, the average number of fruits detached per position was and in 32 an improved method it was 100.

The time required for shifting per position

The time required for shifting per position in the improved method was 3 min and 1.52 min for the traditional method. The time required for shifting of improved harvesting system was more because balancing of tripod takes time. The research efforts are carried out to develop harvesting system for small orange orchards. It was seen that improved system is easy to assemble and no skilled workforce was required to operate the harvesting system. The shifting time for the system was higher, but it was justified by better ability to cover maximum fruit trees from a single position.

The harvest rate was observed lower compared to the traditional harvesting method, but the traditional method resulted in more fruit damage while improved method has no fruit damage. The better selection of matured fruits was possible with the help of necked eyes and physical properties of fruits. As the whole system assembly mounted on telescopic tripod, no load is carried by the operator thus reduces.

References

Li, P., Lee, S.H. and Hsu, H.Y., 2011. Review on fruit harvesting method for potential use of automatic fruit harvesting systems. Procedia Engineering, 23, pp.351-366.

Młotek, M., Kuta, Ł., Stopa, R. and Komarnicki, P., 2015. The effect of manual harvesting of fruit on the health of workers and the quality of the obtained produce. Procedia Manufacturing, 3, NHB. 2015. Area and Production Statistics.
Retrieved Aug 4, 2017, from National Horticulture Board. http://nhb.gov.in /area%20_production.html Sabale, (2017). Development of manual orange (citrus sinensis) Fruit Harvesting pp.1712-1719 System, CTAE, Rajastan PP 3427-3433.
Sanders, K.F., 2005. Orange harvesting ystems review. Biosystems Engineering, 90(2), pp.115- 125

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