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Performance evaluation of developed manual nutmeg *(Myristica fragrans* Houtt.) harvesting system

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■ **ABSTRACT :** Nutmeg (*Myristica fragrans* Houtt.) is an important tree spice which produces two different spices namely nutmeg and mace. The Konkan region is well regarded as fruit belt of Maharashtra. Presently, the method adopted for harvesting nutmeg in Konkan region is by manual means *i.e.* by hand picking, by shaking the tree branches or by using bamboo stick having a curved hook. It was, therefore, necessary to develop harvesting system with simple design, easy for operation, low cost but with higher working efficiency. In view of the present investigation was carried out at Department of Farm Machinery and Power, College of Agricultural Engineering and Technology, DBSKKV, Dapoli. The developed nutmeg harvesting system consists of fruit harvester, telescopic pole, harvesting platform and fruit collecting basket. The performance of developed nutmeg harvesting system was evaluated in field and it's harvesting capacity and damage fruit per cent was found to be 8.15 kg/h and 1.33 per cent, respectively and only one person was required for harvesting operation. The harvesting capacity and fruit damage per cent was found to be 4.37 kg/h and 10.92 per cent for hook method also 1.74 kg/h and 14.85 per cent for beating of fruits by bamboo stick method, respectively and two person were required for harvesting operation in traditional method. The cost of harvesting nutmeg with developed manual nutmeg harvesting system, hook method and beating of fruits by bamboo stick was found to be Rs./kg 5.93, 17.16 and 43.10, respectively. The developed nutmeg harvesting system proved to be superior, efficient and economical over traditional harvesting method.

■ **KEY WORDS :** Nutmeg, Harvesting methods, Performance evaluation, Cost economics

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Nutmeg belongs to the family Myristicaceae which is a small group comprising 16 genera and about 380 spices. It is an important tree spice which produces two different spices namely nutmeg and mace and pericarp is not processed usually as improper harvesting damages pericarp. It is mainly distributed to the low land tropical forests of the world. Nepal, Bhutan, Grenada, Sri Lanka, Malaysia, Indonesia and Guatemala are major nutmeg growing regions. Guatemala is world's largest producers of nutmeg (24,000 MT) which contributes 32.44 per cent of the world's total production. In India, it has occupied an area of about 19,670 ha with an annual production of 18,070 MT. It is grown in Tamil Nadu, Kerala, Karnataka, Assam, Andhra Pradesh, Konkan region in Maharashtra and Goa (Anonymous, 2016).

The female nutmeg tree starts fruiting from sixth year, till the peak period is reached after 20 years. The fruits are ready for harvest in about 9 months after flowering. The peak harvesting season is during June to August. The fruits are considered as ripened and ready for harvesting when the pericarp splits open. If the ripped fruits are left on tree then there are chances of birds getting attracted towards the mace and nutmeg fruit gets carried by bird and rodent. All the fruits on the tree do not mature at the same time and hence, harvesting has to be carried as per ripening of fruit (Anandaraj *et al*., 2005). The nutmeg fruits are harvested on time and at the proper stage of maturity in order to maintain their nutrients level as well as attaining desirable quality. The proper handling, packaging, transportation and storage reduce the post harvest losses. Numerous biochemical processes continuously change the original composition of the fruits until it becomes unmarketable. Nutmeg fruits are very delicate and perishable in nature at the time of maturity, they fall down the ground and deterioration takes place. To increase the market value and shelf-life of the fruits, it has to harvest at proper time. If harvested properly, without damage the pericarp can be further processed *viz.*, pickle, candy, jam, jelly etc. as value addition. Unscientific harvesting results in damage of crop by bruising which can be caused by compression, impact or vibration. During harvesting, factors like delicacy of crop, maturity criteria, time of harvesting, mode of packaging and transportation, economy of operations should be taken in consideration.

In other hands nutmeg fruits with relatively weak peduncles and shaking a branch will produce enough momentum in the fruit to break its peduncle. The most common tool for shaking is a simple hook or gaff on a pole with which to hold and shake the branch. Sometimes beating with a stick may suffice. Presently, the manual harvesting method is adopted for nutmeg in Konkan region of Maharashtra state (India) *i.e*. by hand and another method of harvesting is to hit the fruits by stick. Hand picking is very troublesome and time consuming while the hitting the fruits with stick causes mechanical damage to the fruit that makes the fruit unfit for further processes (Anonymous, 2017).

During surveying of nutmeg plantation, it is observed in nutmeg plant approximately 70 per cent fruits are located between 2.5 to 7 m from ground and outside surface of the plant similarly, 20 per cent fruits located upto 2.5 m height from ground and inside the plant canopy. Average height of the plant was found 9.2 m. The above mentioned nutmeg plant characteristics was considered for design of developed harvesting system in terms of height of harvesting platform, length of telescopic pole, shape and strength of fruit harvester and capacity of fruit collection net.

Hence, a study was conducted to evaluate the field performance of developed manual nutmeg harvesting system and compared with traditional nutmeg harvesting methods *i.e*. beating of fruits by bamboo stick and hook method. The experiment was carried out at Department of Farm Machinery and Power, College of Agricultural Engineering and Technology, Dr. BSSKKV, Dapoli, Dist. Ratnagiri (Maharashtra), India.

METHODOLOGY

Considering the drawbacks of the traditional two existing methods a manual nutmeg fruit harvesting system was developed. Single man can operate it. The system consists of fruit harvester, telescopic pole, harvesting platform, and fruit collecting basket. The operator locate the matured fruits in V-shaped picker hook and fruit was gently pulled with little force and collect the harvested fruits in collecting net then to fruit collecting basket. The harvested fruits are transported from field to storage house or further process. The operator can increase or decrease the length of telescopic pole as per requirement.

Developed harvesting system is used to harvest matured nutmeg fruit manually. In this method, fruits can be harvested by three different ways as per the requirement. The first one is to harvest the fruit from ground surface by hand picking upto operator reach. The second way is to use fruit harvester with telescopic pole upto 4 m height from operator shoulder. The height of telescopic pole can be increased or decreased as per the operators requirement (Plate A). Third way is use of harvesting platform and harvester with telescopic pole to harvest the fruit located on top portion of the tree or upto height 8.2 m from ground level. The detailed view of developed harvesting system as shown in Plate B. After harvesting, collect the overall harvested fruits in fruit collecting basket and transported from field to store house or further process by using fruit collecting basket. Only matured fruit are harvested. The fruit does not fall and hence, damage to fruit is minimized. The pericarp of such harvested fruit can be used for further processing,

Plate A: Developed manual nutmeg harvesting system without harvesting platform and fruit plucking by hand with developed fruit collecting basket upto operator reach

Plate C : Harvesting nutmeg by beating of fruit by bamboo stick and hook method

Plate B: View of developed manual nutmeg harvesting system and harvested fruit

which otherwise might be waste.

Three different harvesting systems *viz.*, beating of fruits by bamboo stick, hook method (Plate C) and developed harvesting manual nutmeg harvesting system were analyzed the field performance in terms harvesting capacity, damage fruit per cent, harvesting time, labour requirement and harvesting cost. The field performance of above three harvesting method was evaluated as per the standard procedure given Plate A,B and C.

Performance evaluation of developed manual nutmeg harvesting system:

To evaluate the field performance of developed nutmeg harvesting system and traditional nutmeg harvesting methods, test were carried out at the Department of Horticulture farm, DR.BSKKV., Dapoli. Dist- Ratnagiri. To determine harvesting capacity (kg/h), damage fruit per cent (%), total harvesting time (h), labour requirement and economics of developed manual nutmeg harvesting system were determined as per procedure given below. The following observations were taken during field performance of developed manual nutmeg harvesting system.

Harvesting capacity:

Harvesting capacity of developed manual nutmeg harvesting system includes sum of all the fruits harvested with and/or without harvesting platform from ground level with in time. Harvesting capacity was estimated by number or weight of harvested fruits per unit time by using following formula given by Hamam *et al.* (2011).

$$\text{Harvesting capacity}\left(\frac{\text{Nos.}}{\text{h}}\right)=\frac{\text{Total number of fruits harvested}}{\text{Time}} \quad ...(1)$$

And similarly in terms of weight,

$$\text{Harvesting capacity}\left(\frac{\text{kg}}{\text{h}}\right)=\frac{\text{Weight of harvested fruits}}{\text{Time}} \quad ...(2)$$

Damage fruit per cent:

It includes the number of fruits that got damaged due to scratching or by falling down from the tree during harvesting with harvesting platform or without harvesting platform operation. The following formula was used to

calculate the damage per cent of fruit is given by Hamam *et al*. (2011).

Mathematically it was calculated as,

$$\text{Damage fruit per cent} = \frac{\text{No. of fruits damaged during harvesting}}{\text{Total no. of fruits harvested}} \times 100 \quad ...(3)$$

Total harvesting time:

The total harvesting time that required to locate/ positioned and detaching the mature fruits by fruit harvester and collecting them in the fruit collecting basket was measured and recorded. The total harvesting time includes the lost time for moving tool and harvesting ladder between nutmeg trees and branches and the time required to empty net and fill into fruit collecting basket.

Labour requirement:

The labour requirement for picking or harvesting the fruits from the tree, to empty the fully loaded net into the collecting basket and to transport the filled basket to the storehouse or further process was recorded.

Cost economics:

The operating cost of developed manual nutmeg harvesting system includes fixed cost and variable cost. The life of developed manual nutmeg harvesting system and its use per year is considered as 5 years and 240 h/ yr (4 x 30 x 2= 240), respectively.

Fixed cost:

- **Depreciation, Rs./h = (C-S)/(L×H)**
- **Interest @ 5 %, Rs./h = [(C+S)/2]×[i/(100×H)]**

where,

C = Initial cost or cost of machine, Rs.

H = Annual use of machine, hrs

i = Interest rate, %

L = Total life of machine, yrs

S = Salvage value, (10 % of initial cost)

- **Housing, Rs./h = 1.5 % of initial cost**
- **Total fixed cost = 1 + 2 + 3**

Variable cost :

- **Operators cost, Rs./h = Wages of operator/Working hours**
- **Repair and maintenance, Rs./h = 10 % of initial cost**
- **Total variable cost = 1 + 2**

Operating cost:

Operating cost = Fixed cost + Variable cost

RESULTS AND DISCUSSION

The performance evaluation of the developed manual nutmeg harvesting system and traditional methods were found out in terms of harvesting capacity, damage per cent, total harvesting time and labour requirement for nutmeg fruits and the economics of operation developed manual nutmeg harvesting system.

Harvesting capacity:

The average harvesting capacity of developed manual nutmeg harvesting system was found to be 8.15 (±0.63) kg/h (143.33 ±20.5 Nos./h). In developed manual nutmeg harvesting system, the fruits could be harvested from a plant upto the height of 8.2 m from ground with comfort and safely without any injury. The harvesting capacity is higher as increased reach of human labour by device and hence more fruits are harvested within less time. The productivity increased due to saving of time and more time utilized for harvesting of fruit due to higher reach. The results confirm similar trend observed by Hamam *et al.* (2011) and Sapowadia *et al*. (2001) for other fruit harvesting.

The average harvesting capacities found to be for

Table 1 : Harvesting capacity of developed harvesting system and traditional methods cv KONKAN VISHWASHRI, Sughandha and Shrimanti (for 187 trees)

Sr. No.	Harvesting capacity					
	Developed harvesting system		Beating of fruits by bamboo stick		Hook method	
	Kg/h	Nos./h	Kg/h	Nos./h	Kg/h	Nos./h
1.	8.86	167	1.63	27.89	5.11	71.32
2.	7.62	132	1.98	36.79	4.38	73.46
3.	7.98	131	1.63	35.29	3.64	59.11
Sum	24.46	430	5.24	99.97	13.13	203.89
Mean	8.15	143.33	1.74	33.32	4.37	67.96
SD	0.63	20.5	0.20	4.764	0.73	7.74

beating of fruits by bamboo stick and hook methods were 1.74 (±0.20) kg/h (34 Nos./h) and 4.37 (±0.73) kg/h (68 Nos./h), respectively (Table 1). The capacities are lower as more time is lost in locating fruit and fruit collection. The graphical representation of harvesting capacity of different nutmeg harvesting system as shown in Fig. 1.

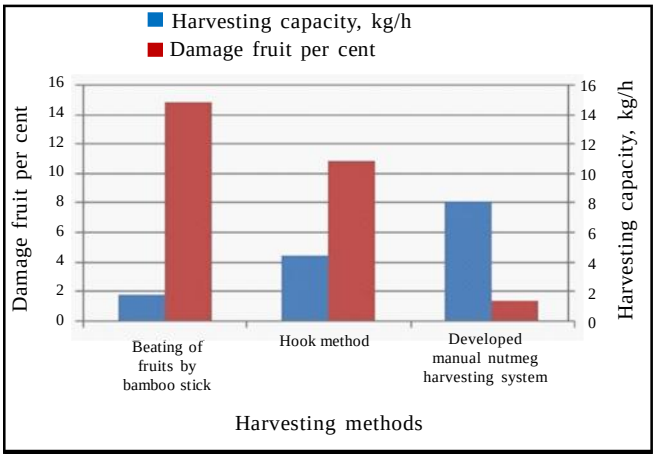

Fig. 1 : Performance of different harvesting methods for nutmeg fruit harvesting

Damage fruit per cent:

The result of the damage fruit per cent during developed harvesting system are presented in Table 2. The average damage fruit per cent while harvesting nutmeg by the developed manual nutmeg harvesting system was found to be 1.33 (±0.42) per cent. This damage per cent included the mechanical damage and fruits falls during harvesting with and without platform from ground surface. The damage to fruit was least as fruit are collected in net and device reach higher elevation and the chances of damage by harvesting and fall was minimum. The results confirm to similar trends observed by Hamam *et al.* (2011).

The average damage fruit per cent of the beating of fruits by bamboo stick and hook method of cv KONKAN SUGHANDHA were calculated as 14.85 (±3.29) and 10.9 (±2.85) per cent, respectively. Damage to fruit may be due to harvesting by stick and falling of fruit from height. The graphical representation of damage fruit per cent of different nutmeg harvesting system as shown in Fig. 1.

Total harvesting time:

The total harvesting time that required for locating and detaching the matured fruits by V-shaped picker hook, and collecting them in the fruit collection net was measured and recorded. The total harvesting time includes the lost time for moving tool and platform between nutmeg tree and branches, time required for climbing and getting up down the harvesting platform and also the time required to empty full fruit collecting basket.

The results of average total harvesting time (h) for developed manual nutmeg harvesting system was found to be 0.12 h/kg. This total harvesting time (h) included

Table 2 : Damage fruit per cent of developed harvesting system and traditional nutmeg harvesting system cv KONKAN VISHWASHRI, Sughandha and Shrimanti (No. of trees- 187)

Sr. No.	Damage fruit, per cent		
	Developed harvesting system	Beating of fruits by bamboo stick	Hook method
1.	1.27	11.32	8.82
2.	1.79	15.38	9.72
3.	0.94	17.85	14.16
Sum	4	44.55	32.7
Mean	1.33	14.85	10.9
SD	0.42	3.29	2.85

Table 3 : Economics of harvesting nutmeg fruits by three different methods

Sr. No.	Harvesting methods	Harvesting capacity, kg/h	Damage fruit per cent, %	labour require-ment	Cost of operation	
					Rs./h	Rs./kg
1.	Developed harvesting system	8.15	1.33	1	48.37	5.93
2.	Hook method	4.37	10.92	2	75	17.16
3.	Beating of fruits by bamboo stick	1.74	14.85	2	75	43.10

the harvesting time (h) and time lost during harvesting (h). The less time required may be due to saving the required time for collecting the fruit from ground surface and time to locate and harvest the fruit from tree. The results confirm to similar trends observed by Hamam *et al*. (2011) and Savjibhai (2016).

The results of average total harvesting time (h) beating of fruit by bamboo stick and hook method were found to be 1.75 h/kg and 4.31 h/kg, respectively. This total harvesting time (h) included the harvesting time (h) and time lost during harvesting (h).

Labour requirement:

The labour requirement in developed harvesting system for picking or harvesting the fruits from the tree, to empty the fully loaded net into the fruit collecting basket and to transport the filled fruit collecting basket to the storehouse or further process. It was found that only one person is required to operate the whole developed manual nutmeg harvesting system.

The labour requirements in traditional harvesting method for harvesting of fruit by bamboo stick and hook method. Similarly labour required to collect the harvested fruit. It was found that two person is required to harvest nutmeg fruit *i.e.* one for harvesting and other for collecting the fruit from ground surface. This collected fruit transported from field to store house or further process by use of bag or basket.

Harvesting cost:

Harvesting of nutmeg fruits was carried out by three different harvesting methods *viz.*, beating of fruits by bamboo stick, hook method and developed manual nutmeg harvesting system. The traditional and developed harvesting system was evaluated based on harvesting cost also. The detail economics of harvesting nutmeg by three different methods are presented in Table 3.

Harvesting cost for developed harvesting system was found to be 5.93 Rs./kg. Also harvesting cost for hook method and beating of fruits by bamboo stick were found to be 17.16 Rs./kg and 43.10 Rs./kg, respectively. Thus, the saving of harvesting cost with the use of developed harvesting system as compared to traditional harvesting method was 576 and 169 per cent, respectively for beating of fruits by bamboo stick, hook method. This was due to higher harvesting capacity, less time required to harvest matured fruit and less labour required with use of developed nutmeg harvesting system. All the performance parameter *viz.*, harvesting capacity, damage fruit per cent, harvesting time, labour requirement and harvesting cost were calculated.

It was concluded that, traditional methods were found more costly as compared to the developed manual nutmeg harvesting system because labour requirement in traditional harvesting methods is two *i.e.* operator wages is high and similarly in developed harvesting system only one operator is needed to harvest the fruit and also harvesting capacity is found high as compared to other traditional harvesting method. Thus, the developed harvesting system is superior as compared to traditional harvesting method.

Conclusion:

– The performance of developed manual nutmeg harvesting system was found to be superior as compared to traditional nutmeg harvesting methods.

– Harvesting capacity of beating of fruits by bamboo stick was found to be 1.74 kg/h (33.32 Nos./h) and harvesting capacity of hook method was found to be 4.37 kg/h (67.96 Nos./h). The fruit damage per cent were found to be 14.85 per cent and 10.90 per cent, respectively.

– The harvesting capacity of developed manual nutmeg harvesting system was found to be 8.15 kg/h or 143.33 Nos./h and the average damage per cent of the developed manual nutmeg harvesting system was found to be 1.33 per cent and damage fruit per cent was very low as compared to traditional nutmeg harvesting devices.

– The harvesting cost of developed manual nutmeg harvesting system was found to be low as compared to traditional method due to lower labour requirement and higher output and saving of 576 and 169 per cent of harvesting cost as compared with beating of fruits by bamboo stick and hook method, respectively.

– Only one person is required to operate the developed manual nutmeg harvesting system and two persons are required in traditional nutmeg harvesting method.

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REFERENCES

Anandaraj, M.S., Devasahayam, T., John Zachariah, B. Krishna Moorthy, P.A. Mathew and Rema, J. (2005). *Nutmeg* (*Extension pamphlet*). Indian Institute of Spices Research, Kozhikode.

Hamam, A. S., EL-Iraqi, M. E., Sharibim, Y. and Awais, T. R. (2011). Design and evaluation of mechanical picking heads for citrus fruits harvesting, *Egypt. J.Agric. Res.,* **89** (4) : 1545-1562.

Sapowadia, B. D., Gupta, R. A., Patel, H. N. and Pund, S. R. (2001). Design and development of a mango harvesting device. *Agric. Mechaniz. Asia, Africa & Latin America*, **32** (1) : 35-37.

Savjibhai, K. P. (2016). Development and performance evaluation of a mango harvesting device. M. Tech Thesis, College of Agricultural Engineering and Technology, Junagadh, Gujarat (India).

WEBLOGRAPHY

Anonymous (2016). *www.mapsofworld.com/world-top-ten/nutmeg-producing countries.html accessed on 9 February, 2016.*

Anonymous (2017). Report on good practices in agriculture: Social partners participation in the prevention of Muscular skeleton disorders. Fruit harvesting accessed on *www.agri-ergonomics.eu on 24 January, 2017.*