



Performance Evaluation of DBSKKV Developed Fruit harvesters for Matured Nutmeg Harvesting

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Nutmeg (*Myristica fragrans* Houtt.) is an important tree spice which produces two different spices. Harvesting should be done at proper stage of maturity in order to maintain their nutrients level as attaining desirable quality. Presently, the method adopted for harvesting nutmeg in Konkan region is done manually. The DBSKKV, Dapoli has developed four different fruit harvesters. The present study was undertaken to evaluate the field performance and check feasibility for harvesting of matured Nutmeg fruits with DBSKKV, Dapoli developed fruit harvesters. The performance of the DBSKKV developed fruit harvesters for matured Nutmeg fruit were evaluated in terms of harvesting capacity (kg/h), damage fruit per cent, total harvesting time (h), labour requirement and economics of Nutmeg harvesting. The average harvesting capacity of Naveen Mango harvester, Nutan Mango harvester, Atul Sapota harvester and Multi fruit harvester for matured Nutmeg harvesting was found to be 51.33 Nos./h (2.79 kg/h), 61 Nos./h (2.78 kg/h), 51.33 Nos./h (2.92 kg/h) and 144.66 nos./h (5.63 kg/h) respectively. The average damage fruit per cent for Naveen Mango harvester, Nutan Mango harvester, Atul Sapota harvester and Multi fruit harvester for matured Nutmeg harvesting were found to be 25.73%, 25.79%, 17.02% and 7.76% respectively. The cost of operation of Naveen Mango harvester, Nutan Mango harvester, Atul Saopta harvester and Multi fruit harvester for matured Nutmeg harvesting was found to be Rs 18.21/kg, Rs 18.44/kg, Rs 17.53/kg and Rs 9.01/kg respectively. Among the evaluated DBSKKV, Dapoli fruit harvesters for matured Nutmeg harvesting, Multi fruit harvester perform better with minimum damage of fruits.

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1. INTRODUCTION

The fruit harvesters developed by DBSKKV, Dapoli are Naveen Mango harvester, Nutan Mango harvester, Atul Sapota harvester and Multi fruit harvester. Harvesting of spice is mainly done by hand. Some tools like hand pruners, a sharp knife, or scissors is also used for harvesting. DBSKKV developed four different fruit harvesters for harvesting of matured nutmeg. Nutmeg (*Myristica fragrans* Houtt.) is an important tree spice which produces two different spices namely nutmeg and mace. It belongs to the family Myristicaceae which is a small group comprising 16 genera and about 380 spices [1]. It is mainly distributed to the land tropical forests of the world. The major nutmeg growing regions are Guatemala and Indonesia. It is also grown in small scale in India (18,070). Nepal, Bhutan, Grenada Sri Lanka, Malaysia and Guatemala are world's largest producers of nutmeg. Guatemala's nutmeg production is about 24,000 MT which represents 32.44 per cent of the world's total production [2]. In India it has occupied an area of about 19,670 ha with annual production of 18/070 MT. It is grown in Tamil Nadu, Kerala, Karnataka, Assam, Andhra Pradesh, Maharashtra and Goa [3]. East Indian nutmegs are superior than that of West Indian type in that they produce better fragrans [4]. Throughout the nutmeg growing tracts of India High amount of variability has been reported with respect to the growth rate and flushing pattern, productivity, shape and size of the leaf, flower size and shape of the fruit and nut [5,6]. The crop improvement studies carried out in the nutmeg growing regions in India have given special emphasis to maximize the yield. A tree producing around 3000 fruits per year along with other economic characters is considered as high yielder [7]. The production of nutmeg in the country is still insufficient to meet the demand of the nation and hence a substantial quality of nutmeg is important causing a huge loss of valuable foreign exchange [8].

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 [9]. The peak harvesting season is during June-August [10]. The fruits are considered as ripened and ready for harvesting when the pericarp splits open [11]. All the fruits on the tree do not mature at the same time and hence harvesting has to be carried as per

ripening of fruits [12]. 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 [13].

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 at its top end to detach a fruit from its pedicle which are present at the top of the tree [14]. Another method of harvesting is to hit the fruits by stick. These methods results in causing mechanical damage to the fruit and also makes the fruits unfit for further processes [15]. Fruit harvesting solutions have been developed since then with the primary focus in improving working efficiency and reducing fruit damage during harvesting [16].

In other hands Nutmeg fruits with relatively weak peduncles and shaking a branch will produce enough momentum in the fruit to break its peduncle [17]. 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 enough for harvesting [18].

Harvesting of the matured Nutmeg fruits in Konkan region done by using bamboo stick and hook method. The traditional Nutmeg harvesting methods ultimately result in loss of considerable energy , less harvesting capacity, higher harvesting time, damage fruit per cent and labour requirement for harvesting operation of Nutmeg is very high [19]. Nutmeg fruit do not matured at same time. Maturation period is different for different Nutmeg fruit [20]. If fruit split open we can concluded that fruit is matured. DBSKKV, Dapoli has developed four different fruit harvesters for harvesting of different matured fruits viz. Mango, Sapota and Cashew nut etc. These DBSKKV developed fruit harvesters namely need to be tested for harvesting of matured Nutmeg fruits and their feasibility for Nutmeg harvesting. The study was undertaken to evaluate the field performance and checking the feasibility for harvesting of matured Nutmeg fruits with the help of different fruit harvesters developed by DBSKKV, Dapoli. The work was undertaken in the Department of Farm Machinery and Power, College of Agricultural Engineering and Technology, Dapoli with the entitled "Performance evaluation of DBSKKV developed

fruit harvesters for matured Nutmeg (*Myristica fragrans Houtt.*) Harvesting". Harvesting capacity, damage fruit per cent, total harvesting time, labour requirement of DBSKKV developed fruit harvesters on matured nutmeg fruit need to be evaluated. The research work is undertaken with objectives to evaluate performance of DBSKKV developed four fruit harvesters for matured nutmeg harvesting and to compare the economics of matured Nutmeg harvesting by DBSKKV developed fruit harvesters.

2. MATERIALS AND METHODS

Considering the drawbacks of the traditional existing methods the four different fruit harvesters which has developed by DBSKKV, Dapoli for harvesting matured fruits was taken for evaluation. The different fruit harvesters viz. Nutan Mango harvester, Naveen Mango harvester, Atul Sapota harvester and Multi fruit harvester. These fruit harvesters need to be evaluated for the harvesting of matured Nutmeg and also economics performance of above listed fruit harvesters need to be evaluated. DBSKKV developed fruit harvesters are used to harvest matured Nutmeg fruit manually with help of wooden bamboo. Single man can operate all these fruit harvesters. In this method fruits can be harvested from ground surface by fruit harvester. Only matured fruits are harvested. After harvesting, collect the overall harvested in fruit collecting basket and transported from field to store house or further process by using fruit collecting basket.

Four different fruit harvesters viz., Atul Sapota harvester, Nutan Mango harvester, Naveen Mango harvester and Multi fruit harvester developed by DBSKKV, Dapoli were analysed the field performance in terms of harvesting capacity, damage fruit per cent, harvesting time, labour requirement and harvesting cost. The field performance of above fruit harvesting method was evaluated as per the standard procedure given Plate A, B, C and D.

2.1 Performance Evaluation of DBSKKV, Dapoli Fruit Harvesters

2.1.1 Field test

The field performance of DBSKKV, Dapoli developed fruit harvesters were carried out at the Department of Horticulture farm, DBSKKV, Dapoli. The performance of DBSKKV developed fruit harvesters for matured Nutmeg fruit will be

evaluated in terms of harvesting capacity (kg/h), damage fruit per cent (%), total harvesting time (h). The following observations were taken during field performance of DBSKKV, Dapoli developed fruit harvesters.



Plate A. Atul Sapota harvester



Plate B. Nutan Mango harvester



Plate C. Naveen mango harvester

2.1.2 Harvesting capacity

Harvesting capacity of different fruit harvesters will be evaluated by number and weight of harvested fruits with in time. The harvesting capacity will be calculated as

Harvesting capacity in terms of weight basis,

$$\text{Harvesting capacity (kg/h)} = (\text{Weight of harvested fruits}) / \text{Time} \dots(1)$$

Similarly harvesting capacity of matured Nutmeg fruit in terms of Number basis,

$$\text{Harvesting capacity (Nos./h)} = (\text{Number of harvested fruits}) / \text{Time} \dots(2)$$



Plate D. Multi fruit harvester

2.1.3 Damage fruit per cent

It will include the number of fruits that would get damaged due to scratching or by falling down from the tree during harvesting operation. Damage fruit per cent will be calculated as

$$\text{Damage percentage} = (\text{No. fruits damaged during harvesting}) / (\text{Total No. of Fruits harvested}) \times 100 \dots(3)$$

2.1.4 Total harvesting time

The total harvesting time that required for locating and detaching the matured Nutmeg fruits by DBSKKV developed fruit harvesters and collecting them in the fruit collection net will be measured and recorded. The total harvesting time includes the harvesting time, time lost during harvesting and also the time required to empty fully loaded fruits in collecting basket. Time required for transportation of harvested fruit from field to store house or further process will be recorded.

2.1.5 Labour requirement

The actual 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 store or further process will be recorded.

2.2 Estimation of Cost of Operation of DBSKKV Developed Fruit Harvesters

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

2.2.1 Fixed cost

1. Depreciation, Rs/h = $(C-S)/(L \times H)$
2. Interest @ 12 %, Rs/h = $[(C+S)/2] \times [i/(100 \times H)]$

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)
- 3. Housing, Rs/h = 1.5 % of Initial cost
- 4. Total fixed cost = 1 + 2 + 3

2.2.2 Variable cost

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

2.2.3 Operating cost

$$\text{Operating cost} = \text{Fixed cost} + \text{Variable cost}$$

3. RESULTS AND DISCUSSION

The performance evaluation of the DBSKKV, developed manual nutmeg harvesting system were found out in terms of harvesting capacity, damage per cent, total harvesting time and labour requirement of nutmeg fruits and economics of operation DBSKKV developed nutmeg harvesting system. DBSKKV developed fruit harvesters are used for harvesting of Nutmeg fruit and single person is required to operate the fruit harvester. It consists of fruit harvester, wooden bamboo, and fruit collecting basket. The fruit harvesters were connected with bamboo by nails at top of bamboo. The height of wooden bamboo is near about 5 m. Fruit harvested up to 5 m height from ground level with fruit harvester and wooden bamboo.

Table 1. Harvesting capacity and damage fruit per cent of DBSKKV developed fruit harvesters

Fruit harvester	Total harvested fruits			Harvesting time, h	Time loss, h	Total harvesting time, h	Harvesting capacity		Damage fruit per cent, %
	Kg	Nos.	Total damaged fruits (Nos.)				Kg/h	Nos./h	
Naveen Mango Harvester	4.94	91.99	24	1.37	0.43	1.80	2.79	51.33	25.73
Nutan Mango Harvester	4.16	71	18.33	1.06	0.43	1.49	2.78	61	25.79
Atul Sapota Harvester	5.37	92.33	15.66	1.22	0.60	1.83	2.92	51.33	17.02
Multi Fruit Harvester	9.46	163.33	12.66	1.03	0.65	1.68	5.63	144.66	7.76

3.1 Harvesting Capacity

The average harvesting capacities of Naveen Mango harvester, Nutan Mango harvester, Atul Sapota harvester, and Multi Fruit harvester for matured Nutmeg harvesting was found to be 2.79 kg/h (51.33 Nos./h), 2.78 kg/h (61 Nos./h), 2.92 kg/h (51.33 Nos./h) and 5.63 kg/h (144.66 Nos./h) respectively (Table 1). The results confirm similar trend observed by Hamam et al. [21] and Sapowadia et al. [22] for other fruit harvesting. The graphical representation of harvesting capacity of different nutmeg harvesting system is as shown in Fig. 1.

3.2 Damage Fruit Per Cent

The result of the damage fruit per cent during harvesting system are also presented in Table 1. The average damage fruit per cent for Naveen Mango harvester, Nutan Mango harvester, Atul Sapota harvester and Multi Fruit harvester were found to be 25.73%, 25.79%, 17.02% and 7.76% respectively. This damage per cent included the mechanical damage and fruits falls during harvesting of matured nutmeg with DBSKKV developed fruit harvesters from ground surface. The results confirm to similar trends observed by Hamam et al., [21] and Makawana [15]. The graphical represented of damage fruit per cent of different harvesters as shown in Fig. 1.

3.3 Total Harvesting Time

The total harvesting time that required for locating and detaching the matured Nutmeg fruits by DBSKKV developed fruit harvesters and collecting them in the fruit collection net will be measured and recorded. The total harvesting time includes the harvesting the harvesting time, time lost during harvesting and also the time required to empty fully loaded fruits in collecting basket. Time required for transportation of harvested fruit from field to store house or further process will be recorded. The results of harvesting time (h), time loss during harvesting (h), and total harvesting time (h) was analysed and presented in Table 1. The average total harvesting time (h) for DBSKKV developed Naveen Mango harvester, Nutan Mango harvester, Atul Sapota harvester and Multi Fruit harvester to harvest 1 kg fruits were found to be 0.55 h/kg, 0.67 h/kg, 0.54 h/kg and 0.59 h/kg respectively. The results confirm to similar trends observed by Savjibhai [23].

3.4 Labour Requirement

The labour requirement in DBSKKV developed fruit harvesters is 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

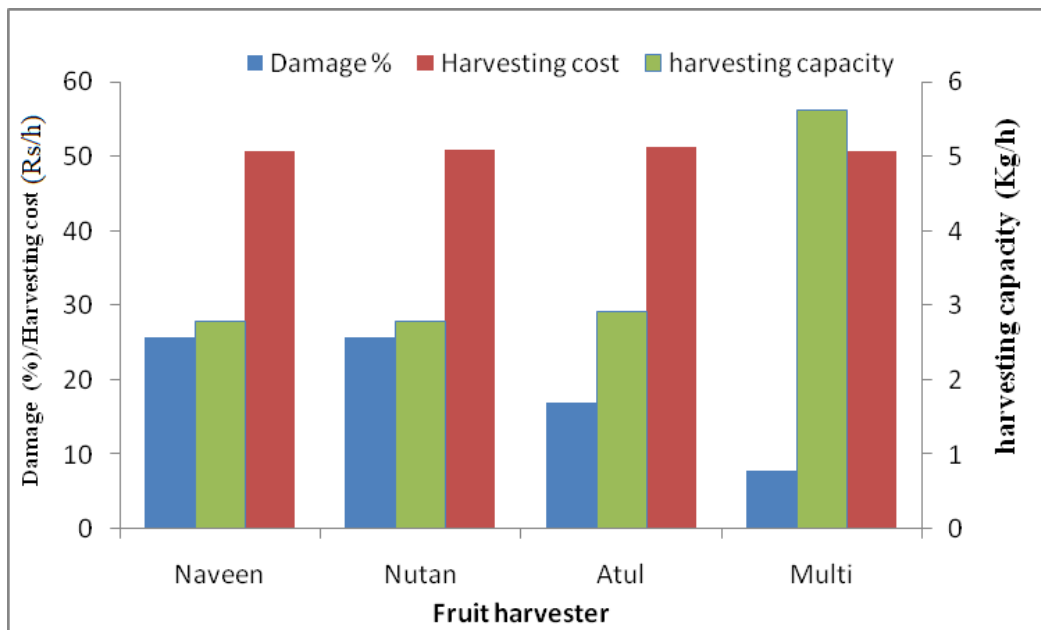


Fig. 1. Comparative performance of DBSKKV developed fruit harvesters for matured Nutmeg harvesting

Table 2. Economics of matured nutmeg harvesting by DBSKKV developed fruit harvesters

Sr. No.	Harvesting methods	Harvesting capacity, kg/h	Damage fruit per cent, %	labour requirement, Nos.	Cost of operation	
					Rs/h	Rs/kg
1.	Naveen Mango harvester	2.79	25.73	1	50.81	18.21
2.	Nutan Mango harvester	2.78	25.79	1	50.91	18.31
3.	Atul Sapota harvester	2.92	17.02	1	51.21	17.53
4.	Multi Fruit Harvester	5.63	7.70	1	50.78	9.01

further process. It was found that only one person is required to operate the DBSKKV developed fruit harvesters for matured nutmeg harvesting.

3.5 Economics of Matured Nutmeg Harvesting by DBSKKV Developed Fruit Harvesters

Harvesting of nutmeg fruits was carried out by four different harvesters developed by DBSKKV. The total cost was determined by straight line method. The detail comparison of economics of four different harvesters is presented in Table 2 and graphically in Fig. 1.

It is observed that harvesting capacity of Multi Fruit harvester is higher as compared to other three harvesters and damage fruit per cent is also low in Multi Fruit harvester than other three fruit harvesters. The cost of operation of Naveen Mango harvester, Nutan Mango harvester, Atul Sapota harvester and Multi Fruit harvester are Rs 18.21/kg, Rs 18.31/kg, Rs 17.53/kg and Rs 9.01/kg respectively.

4. CONCLUSION

The average harvesting capacity of Naveen Mango harvester, Nutan Mango harvester, Atul Sapota harvester and Multi Fruit harvester were (2.79 kg/h), (2.78 kg/h), (2.92 kg/h) and (5.63 kg/h) respectively and the average damage fruit per cent were 25.73%, 25.79%, 17.02% and 7.76% respectively. The Multi fruit harvester performance for matured Nutmeg harvesting was found better than other three in term of performance and economic operation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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