Range Management and Agroforestry 46 (1) : 137-144, 2025
ISSN 0971-2070 (Print); 2249-5231 (Online)
https://doi.org/10.59515/rma.2025.v46.i1.19

Research article

Effect of picker roller diameter and bristle length in the experimental test rig and the development of mechanical type neem fruit (*Azadirachta indica*) picker collector

Suthakar Balakrishnan[1*], Gowtham Manoharan[1], Surendrakumar Allimuthu[2], Kavitha Ramasamy[2] and Masilamani Poomaruthai[3]

[1]Agricultural Engineering College and Research Institute, Tamil Nadu Agricultural University, Kumulur -621712, India
[2]Agricultural Engineering College and Research Institute, Tamil Nadu Agricultural University, Coimbatore -641003, India
[3]Sugarcane Research station, Tamil Nadu Agricultural University, Trichy- 639115, India
[*]Corresponding author email: suthakar@tnau.ac.in

Received: 05th January, 2024 Accepted: 05th March, 2025

Abstract
Manual collection of neem fruit is time-consuming, labor intensive and costly, with cost of collection exceeding the selling price. Hence, an investigation was carried out to test the efficiency of pertinent machine variables *viz.* three levels of picker roller diameter (152, 204, and 250 mm) and three levels of bristle length (30, 40, and 50 mm). A prototype neem fruit picker collector was developed based on the optimized parameters of major components, *viz.*, picker assembly, collector assembly, fruit ejector, connector frame, traction wheels and handle. The developed prototype in actual field conditions can be collected. 48 kg of neem fruit per hour with 75% picking efficiency and, 94% collection efficiency and 24.30% of missing index. Thus, it offers a more efficient alternative to manual collection.

Keywords: Bristle, Neem harvesting, Picker collector, Picker roller diameter, picking and conveying efficiency

Introduction
Neem (*Azadirachta indica A. Juss*) is a tropical evergreen tree widely found in India, thriving in arid to subtropical climates (Meena and Nagar, 2018). India leads global neem production, primarily in Tamil Nadu, Uttar Pradesh, and Karnataka (Masilamani *et al*., 2000), with an annual output of 4.4 lakh tonnes of seeds, yielding 88,440 tonnes of oil and 3.5 lakh tonnes of cake (Ogbuewu *et al*., 2011). Neem is primarily propagated through seeds (Masilamani *et al*., 2023) and is widely used for soil conservation, shade, windbreaks, insecticides, oil, soap, forage, fuelwood (Kumaran *et al*., 1994; Pandey *et al*., 2010; Naugraiya *et al*., 2019; Noor *et al*., 2020; Rashmi and Kala, 2021), and traditional medicine (Bandyopadhyay *et al*., 2004). Neem stores significant biomass carbon (8.97 Mg ha^{-1}) (Singh *et al.*, 2021) and its leaves are important dry-season fodder in Asia (Shukla and Desai, 1988). With 12 to 18% crude protein, the leaves support ruminant livestock in tropical areas with seasonal forage shortages (Fasae *et al*., 2018; Karki and karki, 1993) containing 6.2% digestible protein and 52.5% total digestible nutrients (Patel *et al*., 1962). Neem seeds yield non-edible oil and bio-pesticides rich in limonoids like azadirachtin, nimbin, salanin, and meliantriol (Chhabra *et al*., 2021; Masilamani *et al*., 2004). Neem seed kernel extract is widely used to treat stem rot disease in Egyptian clover (Kaur *et al*., 2023). Azadirachtin, similar to insect hormones, acts as a repellent and feeding inhibitor (Kumar and Navaratnam, 2013), which makes neem vital for pesticide industries(Ogbuewu *et al*., 2011). Oil yields are 20 to 25% from seeds and 40 to 50% from kernels (Kumar *et al*., 2022). Neem trees typically bloom from January to May, with fruits ripening between May and August. Fruiting begins in 3 to 5 years, reaching up to 50 kg annually by the tenth year. (Palaniswamy and Masilamani, 2000 ; Lokanadhan *et al*., 2012). Fallen fresh fruits must be depulped immediately to preserve seed viability (Neeraj *et al*., 2000).
Fruit picking from the ground is primarily done by women using their hands and containers such as buckets, plastic bags, or gunny sacks (Ogbuewu *et al*., 2011), and

tarpaulins are sometimes used to gather wind-fallen fruits (Solanki *et al.*, 2017). Manual harvesting of neem fruits is labor-intensive, yielding only 1.25 kg/h and accounting for 30% of the total harvest time (Tripathi *et al.*, 2022; Gowtham *et al.*, 2024). A female laborer can collect around 10–15 kg/ day, earning Rs. 480 daily (Govt. of Tamil Nadu, 2023). However, with the collection cost at Rs. 32/kg exceeding the market price of Rs. 24/kg, manual harvesting has become economically unfeasible (Tripathi *et al.*, 2022; Gowtham *et al.*, 2024; Balakrishnan *et al.*, 2024; ExportersIndia.com, 2024).

Currently, no mechanical system exists for collecting neem fruits from the ground. To address this, a study was conducted using an experimental test rig to observe the effect of machine variables on picking efficiency, collection efficiency, and the missing index, aiming to optimize these factors for developing a prototype neem fruit picker collector.

Materials and Methods

Experimental test rig for laboratory evaluation: An experimental test rig (Fig. 1) (Balakrishnan *et al.*, 2025) was developed to investigate the influence of the selected levels of variables *viz*. Diameter of picker roller (D), Bristle length (B) on the picking and collection of neem fruits.

Conveyor belt: The endless conveyor belt acts like a moving surface (Kathirvel *et al.*, 2010) for the picker roller, directing the fruits toward the picker assembly. A 2 mm thick polyurethane belt, 8 m long and 0.3 m wide was attached to cylindrical rollers with aluminum rivets. A variable speed drive regulates the belt's speed through a 'V' belt system.

***Power transmission*:** A 1 hp three-phase induction motor, mounted on the right end of the main frame and controlled by a Variable Speed Drive, was selected based on drive pulley diameter (76 mm), driven pulley diameter (305 mm), motor speed (1500 rpm), torque on the driven pulley (19 N·m), and a speed ratio of 4:1.

Fig 1. Experimental test rig developed in laboratory

Variable speed drive: Variable Speed Drive (VSD) that controls the torque, speed and the direction of rotation of the induction motor was connected to a 1 hp three – phase induction motor. By varying the frequency and voltage supply to the induction motor, the speed and torque of the motor was controlled (Kathirvel *et al.*, 2009).

Picker assembly: Picker assembly consisted of a picker roller made of PVC pipe with nylon bristles attached around its periphery and mounted on a frame using the cylindrical shaft. Three sets of roller diameter (6", 8" and 10") with three sets of bristle length (30mm, 40mm, 50mm) were fabricated. For a 10 cm operating width, 500 bristles were fixed on the 6" roller, 620 on the 8" roller, and 780 on the 10" roller.

Collector assembly: The collector assembly included a fruit ejector and a collection box for neem fruits. The fruit ejector was made of 9 nos. of polished mild steel (MS) square rods (4 mm, 200 mm long) welded onto an MS "L" angle (19 mm × 3 mm). The rods were inclined at 50° to the horizontal and positioned between bristle rows to remove fruits during roller rotation. Their free ends were bent inward with a 100 mm radius and sharpened for effective fruit ejection and smooth roller movement.

***Collection box**:* The dimension of the collection box of size 300 x 230 x 230 mm made of MS "L" angle (19 mm × 3 mm) covered by MS sheets with 20-gauge thickness was mounted on a frame made of 10 mm square rod for adjusting in vertical and horizontal direction according to the size of the picker roller.

Experimental design: Laboratory research has been carried out to examine the impacts of pertinent machine variables *viz.* Diameter of picker roller and Bristle length that affect the picking and collection efficiencies and to optimize the variables for developing the prototype of mechanical type neem fruit picker collector.

Diameter of picker roller (D): As the diameter of the picker roller increases, the effective picking area also increases which in turn increases the number of fruits picked by the roller. Hence, three picker roller diameter *viz.*152 mm (6"), 204 mm (8"), and 250 mm (10") were selected for the investigation.

Bristle length (B): The length of bristles on the picker roller significantly influences the number of fruits picked per revolution. As the bristles were made of flexible monofilament nylon material, increase in their length enhances their flexibility which in turn affects the picking efficiency. Hence, three bristle length viz. 30 mm, 40 mm, and 50 mm were selected for the investigation..

Levels of variables: Three levels of picker roller diameter (D1: 152 mm, D2: 204 mm and D3: 250 mm) and three levels of bristle length (B1: 30 mm, B2: 40 mm and B3: 50 mm) were selected for the investigation. Each combination was again replicated (R) thrice (3). Thus total number of treatments (D x B x R) were 27. The picker rollers with different combination picker roller diameter (D_1, D_2, D_3) and the bristle length (B_1, B_2, B_3) are illustrated in Fig 2.

Functioning of experimental test rig: A 100 × 10 cm (0.1 m^2) area was marked on the conveyor belt (Fig 3), and 125 neem fruits were evenly placed within it, maintaining a fixed fruit density. A picker roller of selected diameter was mounted, and the collector assembly was adjusted to position the fruit ejector between the bristles. The conveyor moved at 1.5 km/h while the roller rotated in the opposite direction, picking up fruits, which were then ejected and collected. The number of collected, uncollected, and unpicked fruits was recorded for each trial to evaluate picking and collection efficiency.

Evaluation parameters

Picking efficiency (η_p): Picking efficiency (η_p) can be defined as the number of fruits picked up to the total number of fruits laid on the conveyor belt. It can be calculated using the following equation 1 (Tripathi *et al.*, 2022).

$$\text{Picking efficiency, } \eta_p = \frac{N_p}{N_T} \times 100\,\% \qquad (1)$$

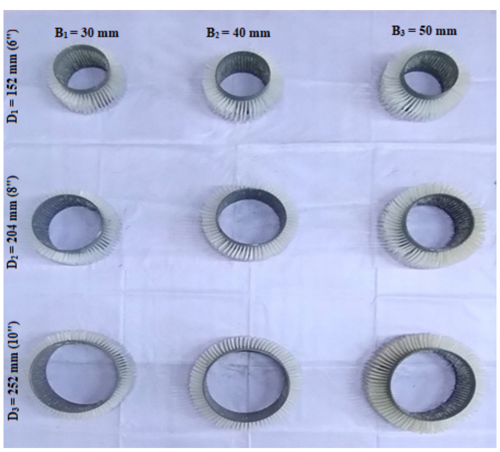


Fig 2. Picker roller with different diameter (D_1, D_2, D_3) and bristle length (B_1, B_2, B_3)

Fig 3. Fruit density of 125/ 0.1m^2 in a 100 cm × 10 cm plot

where, N_T = Total number of fruits laid on the conveyor, N_p = Number of fruits picked by the picker roller

Collection efficiency (η_c): Collection efficiency (η_c) can be defined as the number of fruits collected in the collection box to the number of fruits picked by the picker roller. It can be calculated by the following equation 2.

$$\text{Collection efficiency, } \eta_c = \frac{N_c}{N_p} \times 100\,\% \qquad (2)$$

where, N_c = Number of fruits collected in the collection box; N_p = Number of fruits picked by the picker roller; N_T = Total number of fruits laid on the conveyor

Missing index (M_i): Missing index (M_i) can be defined as the sum of unpicked fruits (N_{up}) and uncollected fruits (N_{uc}) to the total number of fruits laid on the conveyor (N_T). It can be calculated using the following equation 3.

$$\text{Missing index, } M_i = \frac{N_{up} + N_{uc}}{N_T} \times 100\,\% \qquad (3)$$

Where N_{up} = number of unpicked fruits; N_{uc} = number of uncollected fruits; N_T = Total number of fruits laid on the conveyor.

A total of 27 experiments were conducted using the test rig with selected variable levels. Picking and collection efficiencies for neem fruits were recorded and analyzed using 'Minitab' software to perform ANOVA on independent variables such as picker roller diameter (D) and bristle length (B). Levels of variables were optimized to achieve maximum picking efficiency and collection efficiency

Results and Discussion

The Analysis of Variance (ANOVA) obtained using 'Minitab' software was recorded (Table 1). The operational parameters such as picker roller diameter (D) and bristle length (B) significantly influenced the picking efficiency and missing index at the 1% probability level. Additionally, picker roller diameter and bristle length significantly affected the collection efficiency at the 1 and 5% probability levels, respectively.

Linear regression model: The multiple linear regression equation for the effect of diameter of picker roller and bristle length on picking efficiency, collection efficiency and missing index were recorded and also depicted graphically in Fig 4.

$$Y_1 = 57.087 + 0.125\,(X_1) - 0.395\,(X_2) \qquad (4)$$

R_2 = 0.905 ** R_2 (adjusted for DF) = 0.897 **

(** Significant at 1% level)

$$Y_2 = 92.65 + 0.03\,(X_1) - 0.067\,(X_2) \qquad (5)$$

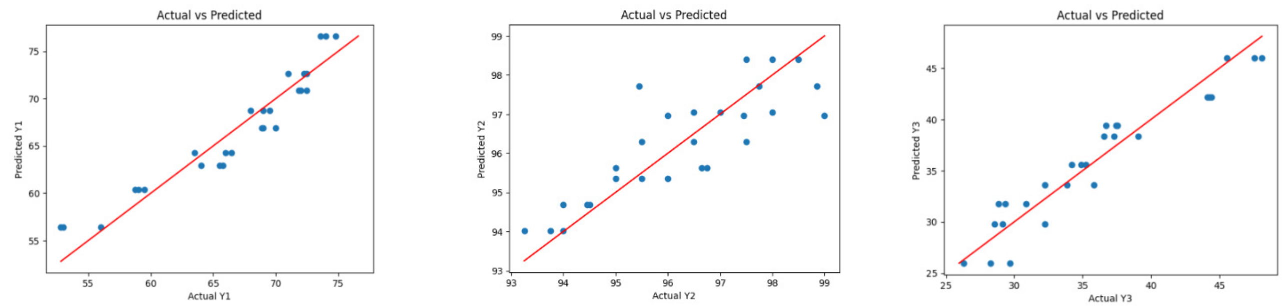
R_2 = 0.707* R_2 (adjusted for DF) = 0.683 *

(* Significant at 5% level)

Table 1. ANOVA for selected levels of variables

S. No.	Variables	DoF	Picking efficiency		Collection efficiency		Missing index	
			MS	F - value	MS	F - value	MS	F - value
1.	Diameter of picker roller (D)	2	366.59	164.88**	21.90	27.03**	365.98	163.23**
2.	Bristle length (B)	2	140.74	63.30**	4.25	5.25*	132.07	58.90**
	Error	22						
	Total	26						

**(($p < 0.01$); *($p < 0.05$); ns: Not significant



Picking efficiency | Collection efficiency | Missing index

Fig 4. Linear regression model for the effect of diameter of picker roller and bristle length

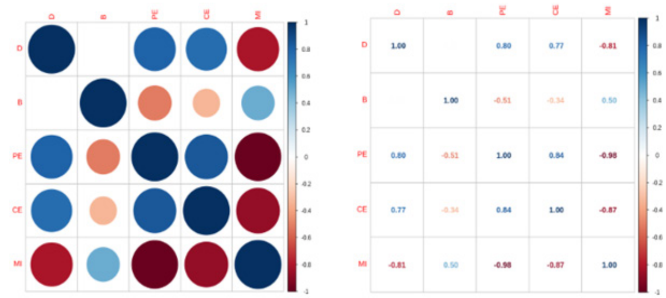
$$Y_3 = 46.18 - 0.126 (X_1) + 0.380 (X_2) \quad (6)$$

$R_2 = 0.91^*$ R_2 (adjusted for DF) = 0.905 *
(*Significant at 5% level)

where, Y_1 - Picking efficiency (%); Y_2 – Collection efficiency (%); Y_3 – Missing index (%); X_1 - Diameter of picker roller (mm); X_2 - Bristle length (mm).

It was noticed that the R-square value of 0.905 (Equ.4) was significant at 1% level of probability of picking efficiency and the R- square values of 0.70 (Equ.5) and 0.91 (Equ.6) were significant at 5% level of probability on collection efficiency and missing index respectively.

Correlation plot: A correlation plot was used to visualize the relationships between multiple variables in a data set. The correlation plot for the effect of diameter of picker roller and bristle length on picking efficiency, collection efficiency and missing index is given in Fig. 5.



D - Diameter of picker roller; B - Bristle length; PE - Picking efficiency; CE - Collection efficiency; MI - Missing index

Fig 5. Correlation plot for the effect of diameter of picker roller and bristle length

From Fig 5, it was observed that picker roller diameter (D) had a positive correlation with picking and collection efficiency and a negative correlation with the missing index, indicating a direct effect on efficiency and an inverse effect on the missing index. Bristle length (B) showed a negative correlation with picking and collection efficiency and a positive correlation with the missing index, indicating an inverse effect on efficiency and a direct effect on the missing index.

Effect of diameter and bristle length of picker roller on picking efficiency: The recorded values of picking efficiency for the selected levels of bristle length (B) at selected levels of diameter of the picker roller (D) for a fixed fruit density of 125 fruits per 0.1 m^2 operating at a fixed forward speed of 1.5 km h^{-1} are furnished in Table 2 and depicted in Fig 6.

It was observed that the increase in the diameter of the picker roller from 152 (D_1) to 250 mm (D_3) resulted in 11.89, 17.84 and 21.64% increment in picking efficiency for the selected levels of the bristle length of 30 mm (B_1), 40 (B_2) and 50 mm (B_3) respectively. This may be due to the fact that the increase in diameter of the picker roller led to an increase in the circumferential area of the picker roller which in turn increased the number of picked neem fruits. It was also noticed that picking efficiency was reduced by 21.11, 10.8 and 7.7% with an increase in bristle length from 30 mm (B_1) to 50 mm (B_3) at all selected levels

Table 2. Effect of diameter of picker roller on picking efficiency

S. No	Bristle length (mm)	Picking efficiency (%)			
		R_1	R_2	R_3	Mean
D_1 = 152 mm (6 ")					
1.	30	63.50	66.45	66.00	65.32
2.	40	59.50	58.75	59.00	59.08
3.	50	56.00	52.80	53.00	53.93
D_2 = 204 mm (8 ")					
1.	30	71.85	72.00	72.50	72.12
2.	40	69.00	70.00	68.90	69.30
3.	50	65.50	64.00	65.75	65.08
D_3 = 250 mm (10")					
1.	30	73.60	74.80	74.00	74.13
2.	40	71.00	72.50	72.25	71.90
3.	50	69.50	69.00	68.00	68.83

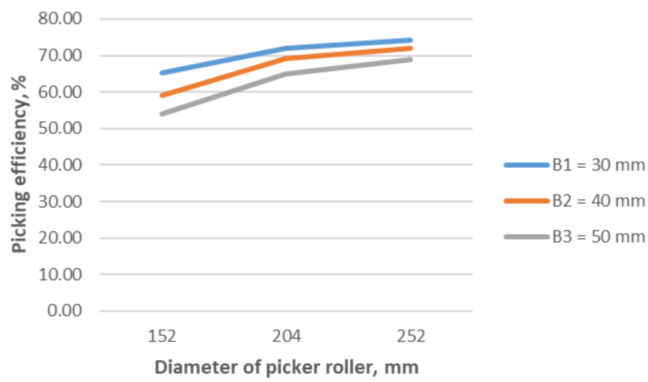


Fig 6. Effect of diameter of picker roller and bristle length on picking efficiency

of the diameter of the picker roller. The minimum value of picking efficiency of 53.93% was observed at 152 mm diameter of the picker roller (D_1) with a bristle length of 50 mm (B_3), whereas 74.13% was observed as maximum picking efficiency at the diameter of picker roller of 250 mm (D_3) with a bristle length of 30 mm (B_1).

Effect of diameter of picker roller and bristle length on collection efficiency: The recorded values of collection efficiency for the selected levels of bristle length (B) at selected levels of diameter of the picker roller (D) for a fixed fruit density of 125 fruits per 0.1 m^2 operating at a fixed forward speed of 1.5 km h^{-1} are furnished in Table 3 and depicted in Fig 7.

It was observed that the increase in the diameter of the picker roller from 152 mm (D_1) to 250 mm (D_3) resulted in 2.55, 3.11 and 3.60% increments in collection efficiency for the selected levels of the bristle length of 30 (B_1), 40 mm (B_2) and 50 mm (B_3) respectively. It may be due to the fact that when the diameter of the picker roller increases, the quantity of picked fruits also increases, which in turn causes the collection of more neem fruits. An increase in bristle length from 30 (B_1) to 50 mm (B_3) resulted in a 1.95, 1.41 and 0.85% reduction in collection efficiency for the selected levels of the diameter of the picker roller. The reason behind this effect may be due to the flexibility of the bristle material. The maximum of 98% of collection efficiency was noted at 250 mm diameter of picker roller (D_3) with 30 mm bristle length (B_1) whereas 93.67% was observed as the minimum value of collection efficiency at 152 mm diameter of picker roller (D_1) with 40 mm bristle length (B_2).

Table 3. Effect of diameter of picker roller on collection efficiency

S. No.	Bristle length (mm)	Collection efficiency (%)			
		R_1	R_2	R_3	Mean
D_1 = 152 mm (6")					
1.	30	96.00	95.50	95.0	95.50
2.	40	94.45	94.00	94.50	94.32
3.	50	93.75	93.25	94.00	93.67
D_2 = 204 mm (8")					
1.	30	99.00	96.00	97.45	97.48
2.	40	96.50	95.50	97.50	96.50
3.	50	96.65	96.75	95.00	96.13
D_3 = 250 mm (10")					
1.	30	97.50	98.50	98.00	98.00
2.	40	95.45	97.75	98.85	97.35
3.	50	96.50	98.00	97.00	97.17

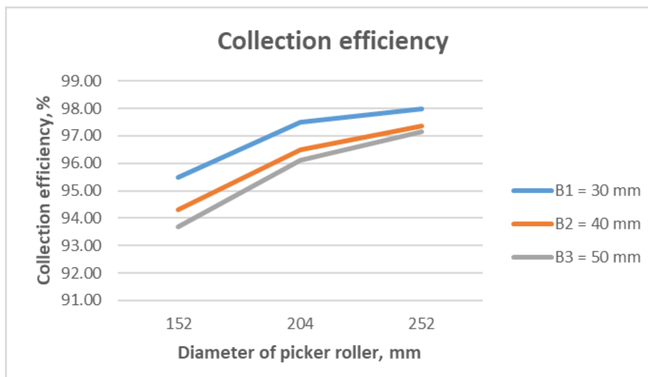


Fig 7. Effect of diameter of picker roller and bristle length on collection efficiency

Effect of diameter of picker roller and bristle length on missing index: The recorded values of the missing index for the selected levels of bristle length (B) at selected levels of a diameter of the picker roller (D) for a fixed fruit density of 125 fruits per 0.1 m^2 operating at a fixed forward speed of 1.5 km h^{-1} are furnished in Table 4 and depicted in Fig. 8.

Table 4. Effect of diameter of picker roller and bristle length on missing index

S. No	Bristle length (mm)	Missing index (%)			
		R_1	R_2	R_3	Mean
D_1 = 152 mm (6 ")					
1.	30	39.04	36.54	37.30	37.63
2.	40	44.40	44.11	44.25	44.25
3.	50	45.54	48.10	47.53	47.06
D_2 = 204 mm (8 ")					
1.	30	28.87	30.88	29.35	29.70
2.	40	35.24	34.20	34.89	34.78
3.	50	36.69	37.44	37.54	37.22
D_3 = 250 mm (10")					
1.	30	28.24	26.32	29.70	28.09
2.	40	32.23	29.13	28.58	29.98
3.	50	32.24	35.83	33.87	33.98

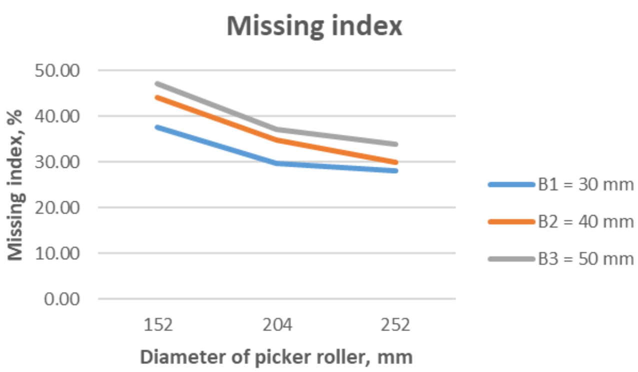


Fig 8. Effect of diameter of picker roller and bristle length on missing index

It was observed that 33.96, 47.6 and 38.48% of the missing index was reduced with an increase in the diameter of the picker roller from 152 (D_1) to 250 mm (D_3) for all the selected levels of the bristle length of 30 (B_1), 40 (B_2) and 50 mm (B_3), respectively. The effect of the diameter of the picker roller over the missing index was due to the fact that the increase in diameter of the picker roller increases the picking area, which in turn reduces the number of missing of neem fruits. It was also noted that an increase in bristle length from 30 mm (B_1) to 50 mm (B_3) resulted in a gradual increment in a missing index by 20.04, 20.22 and 17.34% for all the selected levels of diameter of the picker roller (D). This effect was due to the fact that an increase in bristle length increases the flexibility of the bristle, which in turn picks a smaller number of neem fruits from the conveyor. The minimum value of the missing index of 28.09% was observed for the 250 mm (D_3) diameter of the picker roller with 30 mm bristle length (B_1), whereas 47.06% was found to be the maximum for the 152 mm diameter of the picker roller (D_1) with 50 mm bristle length (B_3).

The treatment with the combination of selected variables that resulted in the desired output was selected as optimized combination levels of the variable, which are furnished in Table 5. The view of the developed prototype mechanical type neem picker collector based on optimized parameters is shown in Fig. 9.

***Construction of mechanical neem fruit picker collector*:** A prototype of mechanical neem fruit picker collector was developed based on the optimized levels of variables. It consists of the picker assembly, collector assembly, fruit ejector, connector frame, traction wheels, and handle. The system was centered on a picking assembly, which includes a 250 mm diameter PVC roller covered with flexible nylon bristles for effective fruit collection. The roller features nearly 2,898 holes with 30 mm long bristles that rotate to pick neem fruits from the ground. The fruit ejector assembly, which was mounted on the picker roller, consists of an array of polished metal rods arranged to remove the fruits from the roller without interrupting its rotation. The fruits were collected in a collector box of size 500 x 300 x 300 mm, made of mild steel (MS) sheets with perforated sides to allow debris to fall out while retaining the fruits. The components

Table 5. Combinations of variables and the optimized values

S. No.	Evaluational Parameters	Combination levels of variables	Value,%
i	Picking efficiency, %	$D_3 - B_1$	74.80
ii	Collection efficiency, %		99.00
iii	Missing index, %		26.30

Fig 9. Mechanical type neem fruit picker collector

Table 6. Results of the performance evaluation

S. No	Particulars	Results
1	Location	Agricultural Engineering College and Research Institute, Kumulur, Trichy
2	Coordinates of the field	10.93175 °N, 78.83256 °E
3	Type of soil	Red loam soil
4	Soil moisture content, %	8.6
5	Operating speed	1.5 km.h^{-1}
6	Effective width of operation, cm	50 cm
7	Field capacity, ha.h^{-1}	0.15
8	Collection capacity, kg.h^{-1}	48
9	Picking efficiency, %	75
10	Collection efficiency, %	94

are connected by a triangular MS frame for stability and mounted on 260 mm diameter traction wheels with 30° lugs for better mobility on uneven terrain. A push handle made of MS round pipe allows ergonomic manual operation, making the device efficient and user-friendly for neem fruit harvesting.

Field evaluation: The developed prototype was operated in the field to evaluate its performance in actual field conditions. The results in field conditions are furnished in Table 6.

Conclusion

The study evaluated the effect of picker roller diameter and bristle length on picking efficiency, collection efficiency, and missing index using an experimental test rig. Results showed that picker roller diameter positively influenced picking and collection efficiency and negatively influenced missing index, while bristle length had the opposite effect. Optimal performance of 74.8% picking efficiency, 99% collection efficiency, and 26.30% missing index was achieved with a 250 mm roller diameter and 30 mm bristle length. Based on these findings, a mechanical neem fruit picker-collector prototype was developed and field-tested, achieving 48 kg/h collection rate, 75% picking efficiency, 94% collection efficiency, and a 24.30% missing index. The prototype reduced collection cost to Rs. 1.5/kg and saved 95% in cost and 97.3% in time compared to the conventional method (Tajuddin *et al.*, 2023).

Acknowledgment

The authors express their gratitude to M/s. Coromandel International Ltd., Chennai, for providing financial support and the Department of Farm Machinery and Power Engineering, Agricultural Engineering College and Research Institute, Kumulur, Trichy, for providing facilities to conduct the research work.

References

Balakrishnan, S., A. V. Tripathi, S. Allimuthu, K. Ramasamy and R. Sivasubramaniam. 2024. Effect of machine and operational parameters on picking and conveying efficiency in an experimental test rig for the development of a pneumatic suction-type ground collection system for neem (*Azadirachta indica*) fruit. *Environmental Engineering and Management Journal (EEMJ)* 23(12).

Balakrishnan, S., M. Gowtham, A. Surendrakumar, R. Kavitha and P. Masilamani. 2025. Effects of forward speed and fruit density on picking and collection efficiency of a neem fruit collector in test rig: effects of variables on neem fruit collection. *Journal of Scientific and Industrial Research* 84: 468-477.

Bandyopadhyay, U., K. Biswas, A. Sengupta, P. Moitra, P. Dutta, D. Sarkar, P. Debnath, C.K Ganguly and R.K. Banerjee. 2004. Clinical studies on the effect of neem (*Azadirachta indica*) bark extract on gastric secretion and gastroduodenal ulcer. *Life Sciences* 75: 2867-2878.

Chhabra, M., B.S. Saini, and G. Dwivedi.2021. Impact assessment of biofuel from waste neem oil. *Energy Sources, Part A: Recovery, Utilization and Environmental Effects* 43: 3381-3392.

ExportersIndia.com. 2024. Neemfruit.https://www.exportersindia.com/product-detail/neem-fruit4377421.htm#:~:text=Neem%20Fruit%20at%20Rs%2024,Sps%20Organics%20India%20Private%20Limited (accessed on Aug.18, 2024).

Fasae, O. A., T.O. Aganto and Jimoh. 2018. Nutritional potentialities of neem (*Azadiractha indica*) plant parts as supplementary feed in ruminant production system. *Nigerian Journal of Animal Production* 45: 301-308.

Govt. of Tamil Nadu.2023. Daily wages for 2023–2024. https://tirunelveli.nic.in/notice/daily-wages-for-2023-2024/ (accessed on Aug.18, 2024).

Gowtham, M., B. Suthakar, A. Surendrakumar, R. Kavitha and P. Masilamani. 2024. Design, Development and evaluation of neem (*Azadirachta indica*) fruit picker cum collector. *Journal of Experimental Agriculture International* 46: 35-45.

Kathirvel, K. and B. Suthakar. 2009. Mechanical harvesting of fodder maize as influenced by crop, machine and operational parameters. *Agricultural Mechanization in Asia, Africa and Latin America* 40: 52-56.

Kathirvel K., B. Suthakar, D. Manokar Jesudas. 2010. Influence of crop, machine and operational parameters on conveying efficiency and inclination of maize stalks in an experimental fodder harvester.

Agricultural Mechanization in Asia, Africa and Latin America 41: 30-35.

Karki, M. and J. B. S. Karki. 1993. Distribution, performance, and utilization of neem in Nepal. In: Proc. *International Consultation on Genetic Improvement of Neem: Strategies for the Future* (Jan 18-22, 1993), Kasetsart University, Bangkok, Thailand. pp. 52-59.

Kaur, M., A. Atri and D. Singh. 2023. Non-chemical management of stem rot disease of Egyptian clover (*Trifolium alexandrinum L.*). *Range Management and Agroforestry* 44: 307-314.

Kumar, S., N. Singh, L.S. Devi, S. Kumar, M. Kamle, P. Kumar and A. Mukherjee. 2022. Neem oil and its nanoemulsion in sustainable food preservation and packaging: current status and future prospects. *Journal of Agriculture and Food Research* 7: 100-254.

Kumar, V. S. and V. Navaratnam. 2013. Neem: prehistory to contemporary medicinal uses to humankind. *Asian Pacific Journal of Tropical Biomedicine* 3: 505-514.

Kumaran, K., M. Palani, R. Jerlin and C. Surendran. 1994. Effect of growth regulators on seed germination and seedling growth of neem (*Azadirachta indica*). *Journal of Tropical Forest Science* 6: 529-532.

Lokanadhan, S., P. Muthukrishnan and S. Jeyaraman. 2012. Neem products and their agricultural applications. *Journal of Biopesticides* 5: 72-76.

Masilamani, P., M. Bhaskaran, C. Chinnusamy and K. Annadurai.2000. Influence of age of mother tree on germination and initial vigour of neem (*Azadirachta indica*). *Journal of Tropical Forest Science* 12: 188-190.

Masilamani, P., S. Selvam and K. Annadurai. 2004. Effect of neem fruit at different maturation levels and depulped seeds on germination and initial seedling vigour. In: Pro*c. IUFRO International Conference on Multipurpose trees in the Tropics: Assessment, Growth and Management* (Nov 22-25, 2004), Jodhpur, India.

Masilamani, P., V.A. Albert, S.Selvam and K. Kumaran. 2023. Effect of different methods of depulping on viability, germination, seedling vigour and its economic analysis in neem (*Azadirachta indica A. Juss.*). *Range Management and Agroforestry* 44: 95-101.

Meena, S. S. and R.P. Nagar. 2018. Evaluation of neem strains and productivity of pearl millet and cluster bean under agroforestry system in semi-arid climate. *Range Management and Agroforestry* 39: 121-125.

Naugraiya, M. N., S. C. Meena and K. Tedia. 2019. Assessment of eighteen years old plantation of *Azadirachta indica* for biomass, nutrient accumulation and soil improvement in Entisols of Chhattisgarh, India. *Range Management and Agroforestry* 40: 118-123.

Neeraj, K., A. K. Saxena and O. P. Rao. 2000. Germination response to collection date and storage methods in neem (*Azadirachta indica A. Juss.*). *Range Management and Agroforestry* 21: 184-192.

Noor, M. B., D. K. Gupta, A. Keerthika and A. K. Shukla. 2020. Biomass production and carbon sequestration potential of neem (*Azadirachta indicaA. Juss*) under dryland environment. *Range Management and Agroforestry* 41: 381-385.

Ogbuewu, I.P., Y.U. Odoemenam, H.O. Obikaonu, M.N. Opara, O.O. Emenalom, M. C. Uchegbu, I. C. Okoli, B. O. Esonu, and M.U. Iloeje. 2011. The growing importance of neem (*Azadirachta indica A. Juss*) in agriculture, industry, medicine and environment: a review. *Research Journal of Medicinal Plant* 5: 230-245.

Pandey, A. K., V. K. Gupta and K. R. Solanki.2010. Productivity of neem based agroforestry system in semi-arid region of India. R*ange Management and Agroforestry* 31: 144-149.

Palaniswamy, P. T. and P. Masilamani. 2000. Development of testing of neem fruit pulper. *Journal Non-Timber Forest Products* 7: 211-213.

Patel, B. M., P. S. Patel and P. C. Shukla. 1962. Nutritive value of neem leaves, mangolds and comfrey. *Indian Journal of Dairy Science* 15: 139-145.

Rashmi, I. and S. Kala. 2021. Rehabilitation of ravine lands with multipurpose tree plantations. *Range Management and Agro forestry* 42: 22-29.

Singh, Y. P., R. B. Sinha, S. Singh and A.K. Singh. 2021. Performance of tree species and natural vegetation after rain water conservation in ravine land based on biomass, carbon stock and soil properties. *Range Management and Agroforestry* 42: 7-14.

Solanki, R. C., S. Santosh, S.P. Singh, S.N. Naik, and A.P. Srivastava. 2017. Design, development and evaluation of neem depulper. *AMA, Agricultural Mechanization in Asia, Africa and Latin America* 48: 45-51.

Shukla, P. C. and M. C. Desai. 1988. Neem (*Azadirachta indica, Juss.*) as a source of cattle feed. I*nternational Tree Crops Journal* 5: 135-142.

Tajuddin, A., M. Parthiban and B. Suthakar. 2023. Computing the Cost Economics of Agricultural Machinery in Farms. *Madras Agricultural Journal* 110: 1-5.

Tripathi, A. V., B. Suthakar, A. Surendrakumar, R. Kavitha and K. Raja. 2022. Design and development of ground collection system for neem fruit. *International Journal of Environment and Climate Change* 12: 2095-2104.