American J. of Engineering and Applied Sciences 4 (1): 179-186, 2011
ISSN 1941-7020
© 2010 Science Publications

Testing and Performance Evaluation of Tractor Mounted Hydraulic Elevator for Mango Orchard

[1]Kishor P. Kolhe and [2]Bhaskhar B. Jadhav
[1]Department of Farm Machinery and Power, Engineering College of Agril, Engineering and Technology, Dapoli, Dist:-Ratnagiri, India
[2]Director of research Konkan Krishi Vidyapeeth, Dapoli, Dist: Ratnagiri: 415 712 (MS), India

Abstract: Problem statement: The harvesting and pruning of horticultural crops is quite difficult due to their tallness. There are small hand tools available for harvesting and pruning. 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 and pruning of horticultural crops 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. To overcome the above problems a Tractor Mounted Hydraulic Elevator (TMHE) powered by tractor PTO, was tested for the mechanical harvesting and pruning of mango orchards using digital load cell, digital Vibration meter and digital Techometer for elevator stability study and pruner engine RPM measurements while in branch cutting respectively. The field performance of the above machine was carried out on plane mango plot, at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist: -Ratnagiri (Maharashtra, India). The machine was tested for the better stability at maximum reach position for harvesting and pruning of various mango varieties, like Alphanso, Totapuri etc. **Approach:** To reduce the harvesting /pruning cost, increase the harvesting/pruning efficiency and enhance the overall productivity of mango orchards. Also to use the traditional mechanized/ manual pruning tools with the developed tractor mounted hydraulic elevator. To develop and refine the power operated mechanism for marginal farmers. This stability study was carried out, by using strain gauge load cell (S-beam), having capacity of 2000 kg. The load cell guiding device was designed and fabricated for conducting the above experiments following standard material specifications of American society of testing material. The reaction on rear wheel of tractor was measured by using digital load cell, which converts the force acting on rear wheel of tractor into electrical signals and get it displayed on the control panel. The speed of pruner engine is measured for various mango trees branches at different heights, using digital tachometer. The vibrations of the pruning platform are measured for the respective pruner engine speed and height of Pruning Platform. The speed and vibration readings are taken for different branches of different diameter and height. The time required for pruning the branches is also measured. **Results:** The tractor mounted hydraulic elevator is most suitable for harvesting and pruning of mango orchards upto 12 m tree height without affecting the stability of machine with available tools. The field capacity of elevator was 0.08 h^{-1} for mango harvesting. The observed field capacity of the developed TMHE is 5,400 mango (1400 kg) day^{-1} for Alphanso mango, research is underway to develop hydraulic man-positioned, which would be easier to harvest, prune tree and spraying by hand or machine. **Conclusion:** The overturning of the elevator is not observed, up to 12 meter height of tree from ground including 150 kg load in the lifting platform for harvesting and pruning of mango orchards. The vibrations of the lifting platform noted are in safe limit.

Key words: Tractor Mounted Hydraulic Elevator, digital vibration meter, pruning tools

Corresponding author: K.P. Kolhe, Department of Farm Machinery and Power Engineering, College of Agril, Engineering and Technology, Dapoli, Dist:-Ratnagiri, India

INTRODUCTION

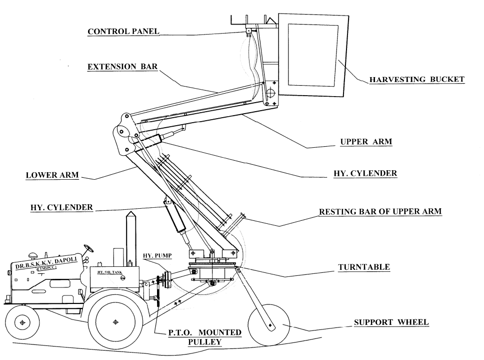
India is an agriculture based country, hundreds of fruit and vegetable types are grown in all parts of India. Last decades have seen the number of Indian fruit, vegetable suppliers and fruit, vegetable exporters rising to an all time high. The total production of fruits and vegetables in the world is around 370 MT. India ranks first in the world with an annual output of 32 MT. Major Indian fruit incorporate mango, banana, citrus fruits, apple, guava, papaya, pineapple and grapes. Konkan region of Maharashtra in India is famous for Alphanso mango, cashew nut, kalipatti sapota fruit and shrivardhanee variety of arecanut. However Mango, cashew nut, kokum, jack fruit, are the major rain fed fruit crops in Konkan region. No other country in the world can surpass India in the number of mango varieties and the richness of the flavours. The climate of the country is ideally suited for mango cultivation. Alphanso is a very famous variety of mango fruit all over the world. The manual harvesting of this fruit is drudgerious and time consuming. During peak season, it is very difficult to get required number of skilled labours. Morever skilled labours for climbing on mango trees are reducing day by day because of drudgery involve in this operation. Hence the Tractor Mounted Hydraulic Elevator (TMHE) Developed by Dr. BSKKV, Dapoli is proposed for harvesting and pruning of mango orchards up to 12 m height of tree. The control panel, attached to the Lifting Platform, controls the height, position and angle of rotation of the Tractor Mounted Hydraulic Elevator.

India is the largest mango producing country, accounting about 60% of world production, the export of fresh fruits are limited to Alphonso and Dashehari varieties of Mango. India's share in the world mango market is about 15%. Mango accounts for 40% of the total fruit exports from the country Mango account for approximately half of all tropical fruits produced worldwide and the worldwide production of mango is 33,445,279 tonnes Manually operated low capacity gadgets and tree-shaking methods of mango harvesting are time consuming, drudgeries, damage fruits and also damage the tree branches(Gupta *et al*., 2004) Mango fruits harvested with 8-10 mm long stalks appear better on ripening as undesired spots on skin caused by sap burn are prevented. Such fruits are less prone to stem-end and other storage diseases (Sapovadia *et al*., 2001). Fadal (2005) Conducted study on Development of a tractor-mounted date palm tree service machine. Two outriggers support the base and other system components to avoid excessive tire pressure while machine is in operation. The base carries a rotating joint in its middle, where a horizontal hydraulic cylinder is used to swing the joint, and the elevator-platform assembly accordingly. Two control panels are installed to control the machine. One of them is located on the base unit, where it may be used from the ground, and the other one is located on the platform to be used by the operator on top. The ground controller controls the out riggers, raising, lowering or swinging the platform. On the other hand, the second control panel, which is placed in the platform where the controller has the ability to control the whole system, including the winch located on the platform. Conducted studies on Mechanical Harvesting of Almond with an Inertia type limb shaker. Mira *et al.* (2008) Conducted studies on Design, construction and testing of an apricot tractor-trailed harvester. In this harvester the two articulated arms at the rear of the chassis, and the wheels are attached at the end of these. These arms move independently on a vertical plane, each of them motioned by a hydraulic cylinder. This movement, combined with the tractor's elevator system, allows for the harvester's leveling in the longitudinal and transverse directions. The trailer's maximum height over the ground is between 0.2 and 1.22 m. This higher clearance allows the unloading of apricots into the boxes or box pallets with a minimum dropping height, preventing fruit damage. The arm-wheel hydraulic cylinders are operated by the tractor's external oil system. Hydraulic controls are located on the left rear side of the trailer. A person walking next to the harvester with a manual branch shaker could also control the trailer hydraulics. The mango harvesting was carried out by pluck-and-drop method with a rod of 3 m long pole with a hook at the end. The pole and collection bag method consist of a plucking technique using a rod of convenient length (1-2 m) equipped with a collecting bag near the hook. The plucked mangos were gathered and selection was made to minimize variation in the sizes. Kolhe (2009) has design and developed a tractor mounted hydraulic elevator for the mechanical harvesting, pruning and spraying of horticultural fruit trees. The testing of the above machine was carried out for harvesting of mango and coconut orchards upto 14-meter height. The comparative study of the TMHE with other available elevators was studied from the literature. The TMHE noted the most suitable results for the harvesting of mango and coconut orchards.The present study was conducted for the stability analysis of tractor mounted hydraulic elevator for various height of Lifting Platform from ground surface and angle of rotation of the tractor mounted hydraulic elevator for harvesting and pruning of Mango Orchards. Whereas the performance of

TMHE was carried out to predict the actual field capacity of the above machine for harvesting and pruning of Mango orchards.

MATERIALS AND METHODS

The stability study of TMHE was conducted using digital strain gauge load cell. The digital load cell (S-beam type) was placed in load cell guiding device with minimum clearance between the two surfaces. The load cell guiding device was designed and fabricated at Dr Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli workshop using mild steel plate of 5 mm thickness using standard material specifications. The composition and mechanical properties of selected material for the fabrication of above load cell guiding device are given in Table1. Ref:- (Kolhe and Datta, 2008). The experimental setup of tractor mounted hydraulic elevator is shown in Fig. 2 a and b.



(a)

(b)

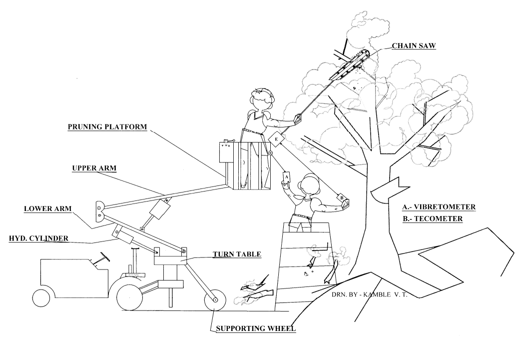
Fig. 1a: Design of Tractor Mounted Hydraulic elevator for harvesting, Pruning and Spraying of Horticultural Crops. (b) Tractor Mounted Hydraulic elevator for harvesting of Mango orchards

The load cell was placed in middle of load cell guiding device in such a manner that the total load of tractor act on the S-beam of load cell. The load cell with load guiding device was kept below the left rear wheel of tractor and the another load cell guiding device without load cell was placed below the right rear wheel of tractor for proper balancing of both wheels. The experimental setup of stability analysis is shown in Fig. 2. The experiments were carried out in different stages by changing the operating parameters of the elevator.

Stage 1: In this stage the height of elevator from ground surface was kept constant at 1.4 meter. The load inside the bucket was kept 50 kg, for set of this condition different reaction on tractor rear wheel were noted on strain gauge display panel by changing angle of rotation from 0-360° at an interval of 30°. For this set the load was varied from 75, 100, 125 and 150 kg respectively.

Table 1: Specifications of 6-20 mm thick mild steel plate

Chemical composition		Mechanical properties	
C	0.25	Tensile strength (N mm^{-2})	410-530
S	0.055	Yield (N mm^{-2})	240
P	0.055	Stress elongation (%)	23
Si	-		
Cu	0.20-0.35		



(a)

(b)

Fig. 2: (a) Experimental Set up of TMHE for Mango Pruning (b) Experimental setup of Tree pruning using Tractor Mounted Hydraulic Elevator

Stage 2- In this stage the height of bucket is increased up to 1.7 m and for varying loads of 50, 75, 100g, 125 and 150 kg with varying angle of rotation from 0-360° the reaction on left rear wheel of tractor were noted from digital display panel of load cell.

Similar types of experiments were repeated for 2.5, 4 and 6 m height of lifting platform. And the reaction on left rear wheel of tractor was noted on digital display panel of strain gauge.

The field performance of TMHE for mango harvesting was conducted on plot No. 13 and 15 of university horticultural mango plot for 18 trees of various mango varieties like Suvarnrekha, Totapuri and Alphanso for finding out the weight of fruits harvested in kg and field capacity of the elevator. The experimental setup of above elevator for Mango harvesting is presented in Fig. 1b.

RESULTS

The results of stability analysis of Tractor Mounted Hydraulic Elevator, using digital load cell for different angle of rotation of turn table in clockwise and anticlockwise direction are presented as in Table 2 and 3. From Table 2, for fixed load of 50 kg and harvesting platform 1.4 m, if the angle of rotation of turn table increases in anticlockwise direction, the reaction on tractor rear wheel decreases. Whereas for the same conditions, if the angle of rotation of turn table increases in clockwise direction, the reaction of tractor rear wheel increases as shown in Table 2. From Table 2. it is observed that for a fixed height of the lifting platform, if the loads in the platform increase from 0-200 at intervals of 50 kg in clock wise direction the reaction of tractor rear wheel increases progressively. Whereas from Table 3 it is observed too similar above experimental set up, if the lighting platform rotated in antilock wise direction at an angle of (0-180°C) at an intervals of 30°C.

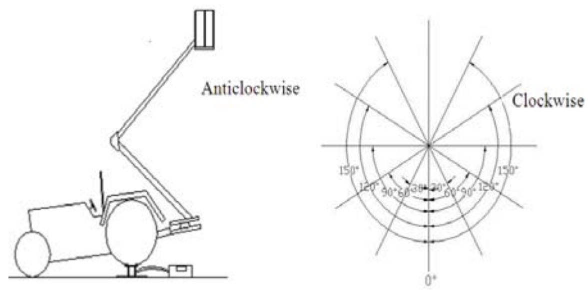


Fig. 3: Experimental set-up for testing the stability of TMHE

Table 2: Reaction on left rear wheel of Tractor in Clockwise direction

SR. No.	Load (Kg)	Height (m)	Reaction on left rear wheel of tractor, Kg Clockwise Ø=0°	Ø1=30°	Ø2=60°	Ø3=90°	Ø4=120°	Ø5=150°
1	50	1.4	395.2	398.3	401.6	404.2	406.7	409.5
	75	1.4	398.6	4010	402.0	404.0	405.0	407.5
	100	1.4	399.4	400.7	403.0	405.6	406.8	407.9
	125	1.4	400.2	402.3	405.3	406.2	407.5	407.6
	150	1.4	402.4	404.3	405.8	407.3	408.3	409.2
2	50	1.7	398.4	399.9	402.3	405.2	407.4	409.7
	75	1.7	401.7	403.2	405.8	406.1	408.7	410.3
	100	1.7	403.8	405.7	407.6	410.4	412.6	412.8
	150	1.7	404.7	406.0	408.2	410.8	413.2	414.5
	150	1.7	405.9	407.8	409.3	411.2	413.3	415.2
3.	50	2.5	400.1	402.0	403.8	406.2	408.3	410.8
	75	2.5	402.3	404.1	406.4	407.8	409.3	411.2
	100	2.5	404.5	406.2	407.8	409.3	411.5	413.4
	125	2.5	406.4	408.4	410.1	412.3	415.3	416.8
	150	2.5	408.6	410.7	411.8	413.2	416.3	418.1
4.	50	4.0	402.7	404.1	405.8	407.1	409.0	410.0
	75	4.0	404.5	406.0	408.3	409.9	411.5	413.4
	100	4.0	406.8	408.6	410.2	412.3	414.3	415.8
	125	4.0	408.2	410.7	411.4	413.6	416.3	418.6
	150	4.0	410.3	413.0	415.8	419.2	420.3	422.3
5.	50	6.0	403.6	405.2	407.4	409.9	411.3	413.8
	75	6.0	404.8	407.3	409.5	412.0	416.3	418.2
	100	6.0	406.2	409.9	411.7	414.0	415.9	421.0
	125	6.0	408.4	412.3	414.2	416.2	418.3	422.3
	150	6.0	410.7	412.3	415.1	417.2	419.5	422.8

Table 3: Reaction on left rear wheel of Tractor in Anticlockwise direction

			Reaction on left rear wheel of Tractor, Kg					
					Anticlockwise			
SR. No.	Load (Kg)	Height (m)	Ø1=0°	Ø1=30°	Ø2=60°	Ø3=90°	Ø4=120°	Ø5=150°
1	50	1.4	395.2	393.4	391.7	389.5	387.4	383.1
	75	1.4	398.6	395.4	394.8	392.2	389.3	387.0
	100	1.4	399.4	395.2	391.8	387.3	386.2	388.4
	125	1.4	400.2	397.2	395.8	392.3	391.4	389.0
	150	1.4	402.4	399.4	397.2	395.3	393.0	391.4
2	50	1.7	398.4	396.1	394.3	391.6	389.2	387.7
	75	1.7	401.7	398.6	396.5	394.3	391.7	389.6
	100	1.7	403.8	401.6	398.5	396.8	393.2	390.8
	150	1.7	304.7	396.2	394.7	391.0	389.8	387.1
	150	1.7	405.7	399.8	397.2	395.0	393.6	391.7
3.	50	2.5	403.8	401.6	399.9	397.0	395.3	393.5
	75	2.5	404.7	403.0	401.2	399.5	397.4	395.0
	100	2.5	405.9	403.2	400.8	397.2	395.3	393.2
	125	2.5	406.1	404.3	402.3	400.5	398.0	396.0
	150	2.5	408.3	407.1	405.2	403.2	401.2	399.4
4.	50	4.0	404.5	402.0	400.4	398.1	396.5	394.1
	75	4.0	406.4	405.0	403.3	401.1	398.3	396.0
	100	4.0	408.6	406.2	404.3	403.0	401.0	398.0
	125	4.0	402.7	400.0	398.2	396.2	394.2	392.3
	150	4.0	404.5	402.1	399.3	397.1	395.3	393.3
5.	50	6.0	406.8	403.5	401.3	399.0	397.3	395.4
	75	6.0	408.2	406.3	404.2	401.3	398.3	397.0
	100	6.0	410.3	408.2	406.3	404.0	402.5	400.8
	125	6.0	412.6	410.2	408.0	406.0	406.4	404.3
	150	6.0	413.8	411.0	409.2	407.3	405.1	403.8

Table 4: Test results of TMHE at Plot number 13 for mango harvesting

		Time (sec)					
Tree No. variety	TH (m)	Lifting	Harvesting	Lowering	T (sec)	NF (Number)	WF (Kg)
Totapuri							
1	10.10	42	158	22	222	32	18 .0
2	9.60	38	331	20	389	48	29.0
3	8.90	32	450	17	500	68	40.0
4	9.81	36	373	21	430	58	25.0
5	10.30	44	447	21	512	72	48.0
6	9.80	39	174	22	235	42	25.0
7	10.50	45	192	22	259	30	15.0
8	8.50	30	472	18	520	70	45.0
9	9.40	32	184	18	234	16	10.0
10	10.30	44	236	19	299	38	15.0
Total		382	3,017	201	3600	474	270.0
Suvarnrekha							
1	10.75	50	314	28	392	50	17.0
2	10.70	46	404	26	476	85	29.0
3	10.10	43	388	24	455	74	27.5
4	10.41	46	334	26	406	64	21.8
5	10.50	47	363	27	437	70	24.5
6	10.90	52	406	30	488	95	32.0
7	9.75	32	416	22	470	65	24.0
8	10.00	36	417	23	476	68	23.0
Total		352	3042	206	3600	571	198.8

Table 5: Test results of TMHE at Plot number 15 for mango harvesting

Tree No. variety	TH (m)	Time (sec) Lifting	Harvesting	Lowering	T (sec)	NF (Number)	WF (Kg)
Alphanso							
1	9.75	28	288	21	337	50	15.80
2	10.30	32	408	26	352	70	19.00
3	9.40	51	282	48	341	56	17.50
4	9.90	29	505	24	408	80	20.00
5	10.75	63	405	29	374	75	18.75
6	10.50	59	269	27	355	65	17.80
7	9.50	48	279	24	351	62	17.00
8	10.30	55	275	24	354	65	19.00
9	9.75	50	287	21	358	67	22.00
10	10.70	60	285	25	370	85	25.00
					3600	675	192.00

TH- Tree height, T-Total time, NF- Number of fruits, WF- Weight of fruit

The reaction of tractor rear wheel decreases. Table 4 and 5 presents the experimental results of tractor mounted hydraulic elevator for Mango harvesting.

The test results of tractor mounted hydraulic elevator for pruning of mango orchards using power operated chain pruner is presented in Table 6.

DISCUSSION

For better stability of the elevator minimum variations in the reaction are needed. Hence for obtaining the minimum variation of reaction it is recommended to use the machine on plain land while in operating condition.

Performance of tractor mounted hydraulic elevator for mango harvesting: From the Table 4 and 5, the maximum and minimum time for Totapuri mango variety noted is 512 and 222 for 10.1 m and 9.81 m tree height for harvesting of 72 and 32 mangos respectively. Whereas for Suvarnrekha the maximum and minimum time noted was 488 and 392 seconds for tree 10. M and 10.75 m tree height for harvesting of 408 and 337 mango respectively. Similarly for Alphanso mango variety the maximum total time of 408 and 357 sec for 9-9 and 9.75 m tree height for harvesting of 80 and 50 mango respectively. It is also observed from the above study that the lifting and lowering time is proportional to the height of mango tree. Nevertheless, the total harvesting time is mostly depends upon the total no of mango incorporated for the individual tree.

Relation of speed of pruner engine and diameter of branch of the tree to be prune: From Table 6 it is observed that for least diameter of tree branch of 2.54 cm, the speed of pruner engine is 8320 rpm, time required for pruning is 50 sec and height of branch from ground is 4.8768 m. Nevertheless, for maximum branch diameter of 25.5 cm, the speed of pruner engine is 9978 rpm, time required for pruning is 205 sec and height of branch from ground is 4.22 m. Figure 4 represents the graph of branch diameter verses pruner engine speed. It is observed from the graph that as branch diameter increases, the speed of pruner engine increases. The graph obtained from actual experimental results is almost linear as seen from Fig. 4. Hence the speed of pruner engine is directly proportional to branch diameter.

Table 6: Test results of tree pruning, using tractor mounted hydraulic elevator and pruning saw

Branch no	Dbp (cm)	Pes (rpm)	Trp (s)	Hbp(cm)
1	10.160	9412	300	518.16
2	09.104	9247	151	533.40
3	09.144	9267	155	579.12
4	17.780	9952	710	533.40
5	02.540	8320	50	487.68
6	11.430	9630	440	304.80
7	08.890	9203	140	457.20
8	08.255	9001	130	457.20
9	05.080	8550	69	420.60
10	06.350	8610	110	335.28
11	06.000	8554	15	305.00
12	12.400	9950	110	325.00
13	11.400	9063	120	310.00
14	06.500	8789	65	315.00
15	07.000	8800	90	358.00
16	08.600	9120	218	380.00
17	11.700	9863	147	123.00
18	06.000	8552	34	268.00
19	07.500	8910	230	236.00
20	10.300	9457	354	270.00
21	09.800	8310	310	210.00
22	06.000	8576	24	420.00
23	08.000	8998	57	440.00
24	04.500	8460	24	470.00
25	10.800	9490	180	510.00
26	12.400	9884	190	423.00
27	25.500	9978	205	422.00

Notations:- Dbp:- Diameter of branch to be prune, Pes:- Pruner engine speed, Trp:-Time required for pruning, Hbp:-height of branch to be prune

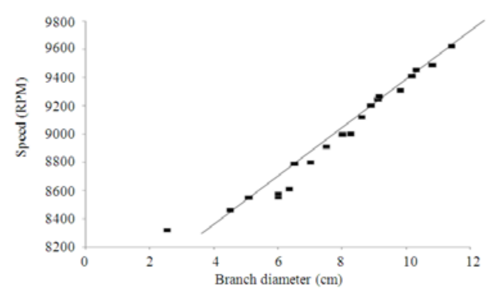


Fig. 4: Influence of branch diameter on speed of pruner engine

The load on cutting saw increases as the diameter of branch increases and ultimately the engine speed increases. From the above graph, it can be concluded that branch diameter is the major parameter influencing pruner engine speed. But the above graph is not exactly linear. Because branch diameter is not the only parameter that influences the engine speed, however other parameters like quality of wood, condition of pruner saw, distance of branch from pruning platform influence the pruner engine speed also.

From Table 6, it is seen that for branch of 6.35 and 12.4 cm, the time required is 110 sec for both the branches. But the pruner engine speed is 8610 and 9950 rpm respectively. The excess speed of 1340 rpm is noted for the same cutting time is due to excess load for bigger diameter branch applied by the operator while cutting. Thus the time required for pruning the branch is same for both the branches of different diameters. Hence it can be concluded that engine speed is directly proportional to branch diameter and the load applied by the operator during pruning.

Influence of pruner engine speed on acceleration of vibrations of pruning platform: Figure 5 represents the graph of acceleration of vibration against pruner engine speed. It can be seen from graph that the minimum values of acceleration of vibrations range in between 0.1-3.2 mm sec^{-2}, while maximum values range in between 0.3-29.9 mm sec^{-2}. It is observed from Fig. 5 that for only four branches the maximum values reach up to 29 mm sec^{-2}. But for the remaining branches the acceleration of vibration values are noted up to 10 mm sec^{-2}. From Table 6 it is seen that the heights of the branches having acceleration of vibration values 29.2, 29.4, 29.3 and 29.9 mm sec^{-2} are 5.1816, 5.334, 5.7912 and 5.334 m, which are highest among all the branches. Thus it can be concluded that the acceleration of vibration increases for higher branches. The pruner engine speed for cutting these branches for which the values of acceleration of vibration as 29.2, 29.4, 29.3 and 29.9 mm sec^{-2} are recorded as 9412, 9247, 9267 rpm and 9952 respectively, which are also higher. Thus it can be seen that for higher speed of pruner engine, higher values of acceleration are obtained. Hence it can be concluded that acceleration of vibration depends on height of branch to be prune from ground and speed of pruner engine.

Influence of pruner engine speed on velocity of vibration of pruning platform: Figure 6 represents the graph of velocity of vibrations of pruning platform against speed of pruner engine. It can be seen from graph that the maximum values of velocity of vibration range from 1-15.9 mm sec^{-2}. While the minimum values are having the range of 0.2-8.5 mm sec^{-1}. It is also observed from the above figure that for more height of tree branch from the ground and the pruner engine speed, the velocity of vibration are high. Thus acceleration of vibration and the velocity of vibration of pruning platform increases, for the more height of branch to be prune with pruner engine speed. Hence it is recommended that the velocity of vibration of such type of machinery may not exceed 18 mm sec^{-1}. The maximum value of velocity of vibration obtained in this study is 15.9 mm sec^{-2}, which is within permissible limit. Hence operation of the pruning in this study is safe for the above mentioned height.

Influence of height of branch to be prune from ground on time required for pruning: Figure 7 presents the graph height of branch to be prune from ground surface verses time required for pruning. From the above graph, it is seen that time required for pruning the branch at highest elevation i.e., of 5.7912 m is 155 sec. While the time required pruning the branch of lowest height of 1.23 m is 147 sec. It can be seen that there is no definite relation between the height of branch to be prune and time required for pruning. The time required for pruning of tree branches varies as per the operator's position and the distance of branch to be prune from the pruning platform. Nevertheless, it is observed from the experiments that for more height of branch if the canopy radius and length of branch is more, then it takes less time to prune the branch. The less time required for prune in above case was noted due to the self average weight of branch which is attracted towards the earth due to gravitational force.

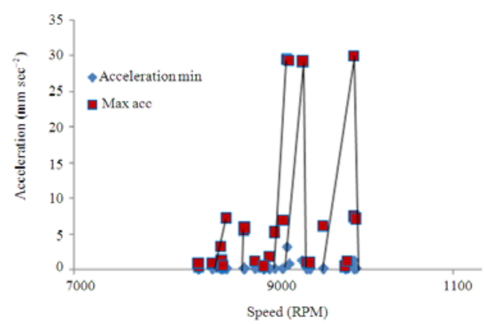


Fig. 5: Influence of speed of pruner engine on acceleration of vibration

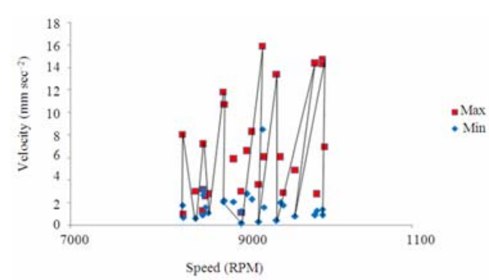


Fig. 6: Influence of speed of pruner engine on velocity of vibration

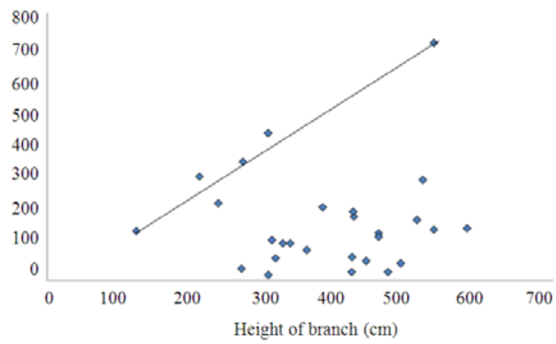


Fig. 7: Influence of height of branch on time required for pruning

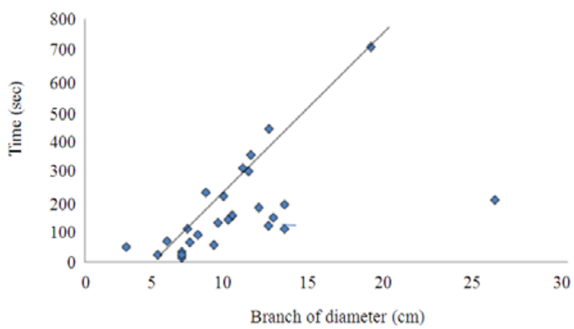


Fig. 8: Influence of branch diameter on time required for pruning

Influence of diameter of branch to be prune on time required for pruning: Figure 8 represents the graph of branch diameter verses time required for pruning in seconds. It is seen from graph that as branch diameter increases the time required for pruning increases. But for the maximum branch diameter of 25.5 cm, the less time of 205 sec is recorded for pruning. These observations are noted for the above branch at 4.22 m height. The less pruning time is recorded due to the maximum sub branches and more overall length of branch. Thus after starting the pruner due to unsymmetrical load, the branch fell down early due to its own weight. And as it was at higher elevation, it fell down with ease. Thus the self weight of branch and height of branch from ground also influence the time required for pruning.

CONCLUSION

- The overturning of the elevator is not observed, up to 12 meter height of tree from ground including 150 kg load in the lifting platform
- The average Alphanso mango fruits harvested per hour were observed 192 kg h^{-1}. (675 fruits h^{-1})
- The average field capacity of TMHE is 0.08 ha h^{-1} (10×10 m)
- The average lifting time required for harvesting bucket to reach up to height of 10.04 m was 38 sec
- The average lowering time required for harvesting bucket to lower down from height of 10.04 m was 28 sec
- The hydraulic elevator is suitable for harvesting of mango and coconut orchard upto 12 m and pruning of tree up to 10 m height comfortably.
- The hydraulic elevator is suitable for operation on plain field as well as hilly terrain having slope upto 20.5%

ACKNOWLEDGMENT

The researchers of this study like to thanks to the Hon. Vice Chancellor, Dr Balasaheb .Sawant Konkan Krishi Vidyapeeth for providing university research facility during the above work. And the Officer In charge coconut research station Bhatye and horticulture Mango Plot, Dapoli for their moral support and sincere help while conducting the experiments on the university mango plot.

REFERENCES

Gupta, R.A., R.M. Satasiya, P. Mohnot and N.K. Gontia, 2004. Development and testing of a tractor-mounted positioner for mango harvesting. Agric. Mech. Asia Afr. Lat. Am., 35: 28-32.

Sapovadia, B.D., H.N. Patel, R.A Gupta and S.R. Pund, 2001. Design and development of a mango harvesting device. Agric. Mech. Asia Afr. Lat. Am., 32: 31-34.

Fadal, M.A., 2005. Development of a tractor-Mounted date palm tree service machine. Emir J. Agric. Sci, 17: 30-40.

Mira, A.T., O. Chaparro, C. Ortiz, J.J. Bernad and E. Orti *et al*., 2008. Design, construction and Testing of an apricot Tractor-trailed harvester. Spnish J. Agri. Res., 6: 333-340.

Kolhe, K.P. and C.K. Datta, 2008. Prediction of microstructure and mechanical properties of multipass SAW. Elsevier J. Mat. Process. Technol., 197: 241-249. DOI: 10.1016/j.jmatprotec.2007.06.066

Kolhe, K.P., 2009. Design and development of tractor mounted hydraulic lifter for harvesting spraying and pruning of horticultural fruit trees. Int. J. Agril. Eng., 2: 170-175.