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Performance Evaluation Of A Mechanical Palm Fruit Harvester Against Two Other Methods, In Palm Fruit Harvesting

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***Abstract*—Palm oil production in Nigeria has been on the decline. A notable factor responsible for this is in the area of harvesting. This work compared a Mechanical Palm Fruit Harvester (MPH), Bamboo-Pole and Knife (BPK), and a Single Rope and Knife Climbing (SRC) methods in harvesting palm fruit. The MPH was made up of a gasoline engine, poles, shafts, hubs and cutting disc with carbide teeth. MPH, BPK and SRC harvesters were evaluated by the harvesting speed, throughput capacity, a statistical analysis package and cost analysis. Harvesting speed results showed that MPH, BPK and SRC took 2.2 hrs/ha, 4.03 hrs/ha and 5.04 hrs/ha respectively, and a throughput capacity of 65 bunches/h, 36 bunches/h and 28 bunches/h respectively. The statistical analysis between MPH, BPK and SRC shows that the effect of height is not significant, while the effect of time is significant. MPH used a litre of fuel which cost ₦ 87 to harvest five (5) bunches, for BPK, at the rate of ₦ 50 per bunch, a total sum of ₦ 250 was paid to the harvester, while a total sum of ₦ 300, at the rate of ₦ 60 per bunch was paid to the harvester using SRC. Field test results showed that MPH method was fastest among the three. It was observed that SRC took the longest time to harvest; this was due to the fact that the harvester had to climb up and down the tree. The cost of harvesting was cheapest with MPH.**

Keywords—Comparison, Palm Fruit, Harvesting, MPH, BPK, SRC

INTRODUCTION

Recently in agriculture, there is a new focus on palm fruit which has to do with the production of bio-chemical which can be used for fuel. Production of petroleum is on the decrease, this is why a country like Nigeria should focus on this palm fruit production. Many researchers within and outside the country believe this fruit is what would be useful and serve as an alternative fuel in some few years to come.

In agriculture, there are two major ways of cultivation; these include the use of labor or machinery. In production the major factors that are always considered include; maximizing profit, increasing productivity and the cost reduction. The use of machineries has been proven to accomplish these conveniently. That is, machinery can help to maximize profit, increase productivity and reduce cost (Muhamad Jamil, 2008).

One of the important activities in palm fruit cultivation is harvesting. Harvesting is the act of removing a crop from where it was growing and moving it to a more secure location for processing, consumption or storage. The major factor to determine the time of harvest is the maturity of the crop. The other factor is weather, availability of harvest equipment, picker, packing and storage facilities as well as transport which is important for consideration.

Harvesting operation requires 60% of total labor for the crop which constitutes about 50% of the total production cost (Muhamad Jamil, 2008). It is well known that the agriculture sector in Nigerian and the palm fruit industry in particular depends very much on labor especially crude labor methods to function in production. From these crude methods, palm fruit production in Nigeria is on the decline and the internally generated revenues of the states within the country is gradually fading out.

Over the years the keyword has always been human or workers, we used to believe only human beings have the unique combination of eyes, brain and hands that permits the rapid identification and harvest of delicate and perishable material with minimal loss and bruising. But now is modern technology, there are many machinery that can help human to do this harvesting. Many harvesting machines have been developed by industrial and agriculture machine manufacturers for harvesting palm fruit bunches. In developing the harvesting machine the most difficult part is to design a suitable cutter for harvesting and pruning. There are several factors that were taken into consideration when developing mechanical harvesters; such as ground pressure, light weight, technique to harvesting, ability to harvest from both high and short palm trees, and the most important is safety of the operator.

The usual practice for harvesting from palm of more than 3 meters high is to attach a sickle into a pole. Many efforts have been expanded in developing various type of cutting devices but the manual method still remains as the most effective way of harvesting. The sickle with its curve design could effectively get access to the fronds as well as the bunch stalks during the harvesting process. In many inventions, the

sickle is still used as the cutting device however the cutting operation is executed mechanically.

The Mechanical Palm Fruit Harvester (MPH)

This has a gasoline engine that uses fuel/oil mixture. It has a pole that houses the shaft which also connects the engine to the cutting disc with the help of the hubs. The adjustment of the pole is based on the height of the palm fruit to be harvested.

The main process of harvesting is done by the cutting disc. The engine transmits torque to the shaft via a hub; this torque is transmitted once the switch is on. This torque causes the shafts to rotate and this rotation is transmitted to the cutting disc. The machine is designed to rotate anti- clock wisely therefore care should be taken when the machine is been assembled by any user. The disc has sharp teeth which helps the cutting head to cut both the palm fronds and the bunch.

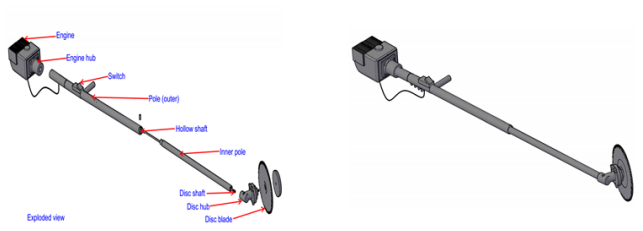

Figure 1: An isometric and an assembled diagram of the mechanical palm fruit harvester

Bamboo Pole and Knife (BPK)

This is made of a bamboo pole and a knife as the cutting head. It is used to harvest palm trees from moderately tall to 9m in height (Adetan *et al*., 2007)

Single Rope and Cutlass/Axe (SRC)

This is a Palm fruit harvesting method that uses a single rope as support around his waist to climb the palm tree, and he is equipped with a knife or a cutlass to cut harvest the bunch when he gets to the top. This method is used to harvest trees beyond the reach of the pole and knife method.

Experimental Procedure

Three people were chosen and plots were allocated to them. The average age of each member was 30 and they had an average weight of 70 kg. It was ensured that these were men with no health challenge who had averagely equal heights.

Tests were carried out with the Mechanical Palm fruit Harvester (MPH), Bamboo, Pole and Knife harvester (BPK) and Single Rope and Cutlass (SRC) methods on randomly selected plots on the oil palm plantation.

The height of each palm tree, time taken and the number of bunches harvested were all noted and replicated. The averages were taken and analyzed.

Depending on the height of trees on the plot, the extension sections of the MPH were appropriately adjusted for effective harvesting. The palm tree heights harvested ranged from 4-12 m. **Evaluation Parameters of the Machines**

This includes harvesting speed, throughput and the efficiency of the machine and the use of statistical analysis package.

Tables 1 shows the performance test on MPH. it was noticed from the performance test carried out that five (5) bunches each were harvested for different heights. A total of 35 bunches of palm fruits were harvested in all. It took 1955 seconds to harvest the 35 bunches, therefore it took an average of 55.85 seconds to harvest a bunch and 65 bunches per hour. This implies that the overall time for harvest and speed for harvest using MPH are 2.2 hrs/ha and 0.45ha/hr respectively.

Table 1: Performance test on MPH

Number of bunches	Average height (m)	Total time (s)	Average time/FFB (s)
5	4	250	50
5	4	255	51
5	6	265	55.6
5	8	278	55.6
5	8	280	56
5	9	300	60
5	10	327	65.4
Total = 35 Average = 5 Standard deviation =	**49 7**	**1955 279.29 25.32**	**391 55.85**

Tables 2 show the performance test on BPK. It was noticed from the performance test carried out that five (5) bunches each were harvested for different heights. A total of 35 bunches of palm fruits were harvested in all. It took 3550 seconds to harvest the 35 bunches, it therefore took 101.43 seconds to harvest a bunch and 36 bunches per hour. This implies that the overall time for harvest and speed for harvest using BPK are 4.03 hrs/ha and 0.25ha/hr respectively.

Table 2: Performance test on BPK

Number of bunches	Average height(m)	Total time (s)	Average time/FFB (s)
5	7	485	97
5	7	485	97
5	8	515	103
5	9	525	105
5	11	625	125
5	4	450	90
5	6	465	93
Total = 35 Average = 5 Standard deviation =	**52 7.43**	**3550 507.14 54.63**	**71093 101.43**

Table 3 shows the performance test on SRC. The table shows that five (5) bunches each, were harvested for different heights. A total of 35 bunches of palm fruits were harvested in all. It took 4480 seconds to harvest the 35 bunches, it therefore took 126.86 seconds to harvest a bunch and 28 bunches per hour. This implies that the overall time for harvest and speed for harvest using SRC are 5.04 hrs/ha and 0.2ha/hr respectively.

Table 3: Performance test on SRC

Number of bunches	Average height (m)	Total time (s)	Average time/FFB (s)
5	4	500	100
5	6	570	114
5	7	580	116
5	9	690	138
5	11	905	181
5	7	580	116
5	8	615	123
Total = 35 Average = 5 Standard deviation =	**52 7.43**	**4440 634.29 124.16**	**888 126.86**

Figure 2 shows the harvesting times at different heights for MPH, BPK and SRC, the highest time was 65.4s at a height of 10m and lowest time was 50s at a height of 4m for MPH. For BPK, the highest time was 125s at a height f 11m, and the lowest was 90s at a height of 4m while the highest and lowest for SRC were 181s and 100s at heights 11m and 4m respectively.

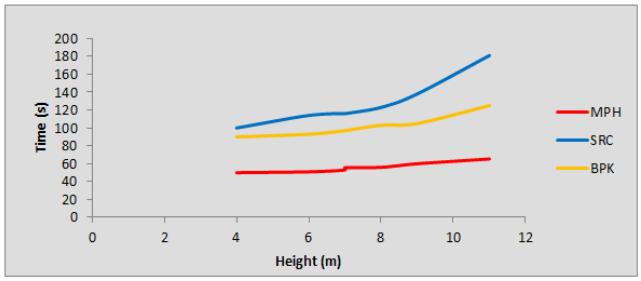

Figure 2: Graph of time against height

Table 4 and Figure 3 compare the throughput values of MPH, BPK and SRC. Throughput is the rate of production, therefore for this study; it is the rate of harvest of palm fruit bunches. This study reveals that the throughput value was highest for MPH at 65 FFB/h, 36 FFB/h for BPK and lowest for SRC at 288 FFB/h. This implies that the rate of harvest of MPH is two (2) times faster than BPK and two and half (2.5) times faster than SRC.

Table 4: Average throughput values of the harvesting methods

Harvest method	Average throughput (FFB/h)
MPH	65
BPK	36
SRC	28

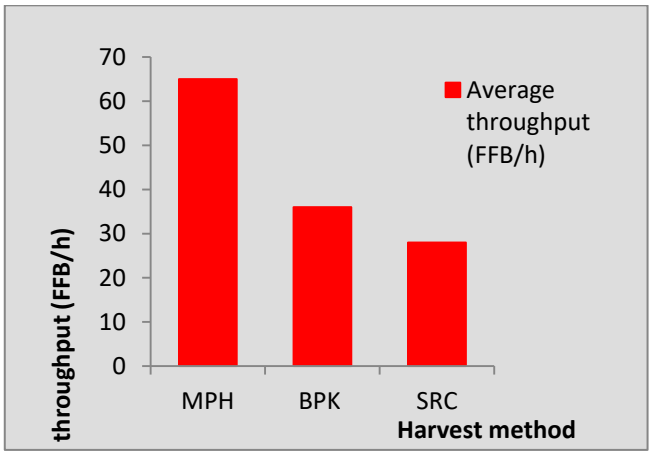

Figure 3: Chart representation of throughput

Table 5 shows the statistical analysis between MPH, BPK and SRC. The result shows that the effect of height is not significant, but the effect of time is significant; this implies that difference in height does not affect the number of bunches affected significantly, while there is a significant effect of time on the number of bunches harvested.

Table 5: Statistical analysis of comparison between MPH, BPK and SRC

VARIABLES	SOURCE	D.F	S.F	M.S	F	P > F
Height	Harvester	2	0.863	0.431	0.083	> 0.92
	Error	102	93.6615.203			
	Total	104	94.524			
Time	Harvester	2	88,665.843	44,332.922	154.044	< 0.00
	Error	102	29,355.008	287.794		
	Total	104	118,020.851			

CONCLUSION

Field tests of the MPH, BPK and SRC methods showed that the MPH method performed much better than the other two methods, in reducing the time spent to harvest. The throughput value was highest for MPH at 65 FFB/h, 36 FFB/h for BPK and lowest for SRC at 28 FFB/h. This implies that the rate of harvest of MPH was two (2) times faster than BPK and two and half (2.5) times faster than SRC.

The time spent to climb up and down in SRC was not necessary because MPH could easily be adjusted to suit the height of the respective palm fruit to be harvested.

It was observed that SRC method took the longest period of time to harvest; this was due to the fact that the harvester had to climb up and down the tree. Aside the longer time been spent, it was also observed that the process could be so tiring as time goes on. The risks of accidental fall require the man to be extremely careful hence slower. Insect bites also made the SRC method unattractive to harvesters.

BPK took a longer time than MPH; this was due to some challenges involved in the usage of BPK. The bending of long and heavy poles made it difficult for the BPK method to be comfortably used in harvesting

tall trees. A long bamboo tree would not easily harvest shorter palm fruits, it was clumsy and the harvester had to continuously manipulate the bamboo tree in other to suit the required height for the palm fruit to be harvested. Similarly, a shorter bamboo would not be suitable to harvest a taller palm fruit. It was also observed that the transportation of heavy BPK method poles to the distant plantations took a lot of the harvester's time and energy and thus drastically reduced his rate of harvesting.

The developed machine had a maximum efficiency of 75% and was obtained at a height of 4m; this was the lowest height considered for this research and it was noticed that the efficiency of the machine reduces as palm tree heights increase. This suggests that the machine could perform even better at lower heights.

This result agrees with the study result from (Aramide *et al*., 2015), which reported the speed of harvest as 66 FFB/h. The cost of harvesting was lowest using MPH at a sum of ₦ 4, 733 per hectare. It was highest in SRC at a cost of ₦ 300 per row and ₦ 8, 580 per hectare, while BPK cost ₦ 250 per row and ₦ 7, 150 per hectare. MPH was found to be cheap and considered more economical than other existing local methods. This would generally reduce the overall harvesting process. Considering the ease of operation, MPH is considered the easiest among the three tested for this research work. Its durability, mobility and operation distinguish it compared to the others. Harvesting palm fruit with the use of the MPH also reduces drudgery while no skill is required.

REFERENCE

Adekoya, L.O. and Makinde, A. 1990. Data acquisition for the mechanization of oil palm

harvesting, *Nigerian Journal of Engineering and Technology* 9 (1): 10 – 28.

Adetan, D.A. and Adekoya, L.O. 1995. Comparison of two methods of manual

harvesting of oil palm (Elaeis guineensis Jacq). *Tropical Agriculture* 72 (1). 44 – 47.

Adetan D.A, L. Adekoya and K. Oladejo. 2007. "An improved Pole and Knife Method

Of Harvesting the Oil Palm". Agricultural Engineering International: the CIGR journal.

Manuscript PM 06027. Vol. IX. pp 1-11

Aramide B.P, Owolarafe, O.K, Adeyemi, N. A. 2015. Agric Eng Int: CIGR Journal Open access

at http://www.cigrjournal.org.

http://cocoaphilippinesblog.blogspot.com.ng/2011/04/harvesting-tools - palmoil.html?m=1

Mohd Hafiz Mohd Hazir, Abdul Rashid Mohammed Shariff. 2011, Research Journal of

Applied Sciences, Engineering and Technology 3(9):953-962.

Muhd Rizdwan Bin Muhamad Jamil. 2008. Design and Fabrication of a Prototype of a

Motorized Cutter for Harvesting Palm Fruit. http://www.core.ac.uk

Onwualu, A.P. Akubuo, C.O. and Ahaneku I.E. Fundamentals of engineering for Agriculture. pp

135- 144

Owolarafe, O.K. and Arumughan, C. 2007. "A review of oil palm fruit plantation and

production under the contract-growers scheme in Andhra Pradesh and Tamil Nadu states of India" *Agricultural Engineering International: the CIGR Ejournal*. Invited Overview No. 4, Vol. IX. March, 2007.Palm Oil Facts and Figures, 2014. http://www.simerdarbyplantation.com

APPENDIX

Plate 1: Bamboo-pole and knife

Plate 2: Single rope and knife/cutlass method

Plate 3: Mechanical palm fruit harvesting