ISSN 2347-4289

Ergonomic Comparision Of Two Groundnut Harvesting And Shelling Methods

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ABSTRACT: An ergonomic study on groundnut production was carried out with five farmers used as subjects. Two harvesting techniques were investigated. Harvesting method I involved involved plucking of the pods from the plant on the field while harvesting method II involved uprooting the whole plant (including pods) after which the pods were plucked from the plants in a sitting posture. Mechanical shelling was performed and compared with manual shelling. The parameters measured on the subjects included heart rate, body temperature, blood pressure, and anthropometric measurements at each working postures. The area of groundnut plots harvested together with the weight of groundnut shelled as well as the time spent in each case were all measured. The field capacities, energy expenditure rate, shelling capacity, spinal extensor muscle force as well as the total reaction on the lumbosacral joint were determined for both harvesting methods. Results obtained indicates that, for harvesting methods I and II, energy expenditure rates for harvesting are 5.3kJ/min and 3.7kJ/min, energy expenditure rates for shelling are 4.5kJ/min and 5.3kJ/min, field capacities are 36m^2/h and 44m^2/h, shelling capacities are 65kg/h and 12kg/h, spinal extensor muscle forces for harvesting are 2.9kN and 2.6kN while that of shelling are 0.5kN and 1.5kN, total reaction on lumbosacral joint during harvesting are 3.1kN and 2.7kN while that of shelling are 0.9kN and 2.0kN. Generally, harvesting method I produced higher values in field capacity, increase in energy expenditure rates, spinal extensor muscle forces and total reaction on lumbosacral joint than harvesting method II, while mechanical shelling produced higher values in shelling capacity and increase in energy expenditure rate, but lower values in spinal extensor muscle force and total reaction than manual shelling. These lower values obtained for the parameters associated with harvesting method II and mechanical shelling mean lower physiological stress which is good for the subject. It is therefore recommended that harvesting method II (uprooting the groundnut plants first and later pluck the nut in a sitting position) and shelling mechanically is a suitable combination of operations that can be adopted in groundnut production whenever a mechanical harvester is not available.

Key words: Harvesting, Groundnut, Ergonomics, shelling, heart rate, Anthropometry,

1 INTRODUCTION

Groundnut (Arachis hypogaeal) also known as peanut or earthnut is an important food crop in Nigeria as well as a vital oil seed crop around the globe. It is important for its nutritional and trade values [3]. Groundnuts are grown in tropical and subtropical climatic regions as well as the warmer parts of temperate regions. It is a low growing annual plant, ranging from 30 to 60cm in height. There are two varieties of groundnuts based on their growing characteristics: (i) bushy branched type, which matures within 3 to 4 months (ii) runner or spreading type, which matures within 4 to 6 months. The timing of harvest is critical since it can greatly affect the yields and nut quality. As the nuts mature and harvest time approaches, the groundnut fields are inspected frequently to examine the pods in order to determine the optimum harvest date. The crop is ready for harvest if the majority of the pods are fully developed and take on a mature colour (dark brown) [6]. Although few mechanized operations exist, local production of groundnut is largely manual planting, harvesting and shelling. The method used in groundnut harvesting in Nigeria is to remove the pods straight from the plants as the harvester stays in a bending position, plucking the pods from each plant is done immediately at the field, after which, the pods are taken to the shelling bay. One plant of groundnut may have between 15 and 20 nuts, depending on the type and variety [3]. Another harvesting method involves removing the whole plants and move them to the shelling bay where the nuts are plucked and shelled. These methods influence the quantity and quality of groundnuts harvested as well as the productivity and health of the farmers[3]. The objectives of this work are (i) to study the ergonomic implications of these harvesting techniques with a view to improving the productivity and health of the Nigerian groundnut farmers. (ii) investigate two harvesting methods which include plucking of the pods from the plant on the field while standing compared to uprooting the whole plant with the pods and pluck in a sitting posture. and (iii) to compare mechanical shelling with manual shelling.

2 MATERIALS AND METHODS

The experiment was carried out at Ugbo okoroafor in opanda, Uzo Uwani local government Area of Enugu state of Nigeria. The land was ploughed, harrowed and divided into ten plots, each 16 x 10 meters. Three groundnut seeds of the were planted in each hole at a spacing of 30 x 75cm on a well drained sandy loam soil, and two varieties (bushy branched type and the runner or spreading type) were used. Each variety was planted on a separate plot of land. The crops were later weeded and sprayed with insecticides. Five male farmers described in Table 1 were used as subjects to do the harvesting and shelling. On the first day of harvesting they were given a plot each to harvest using harvesting method I. The second day of harvesting, they used harvesting method II. The subjects do not smoke, were given equal measured weights of groundnuts to shell and were equally treated with respect to resting and feeding under the same environmental conditions. Both shelling operations were carried out four days after harvesting. The first shelling method was manual and involved packing the nuts in jute bags and gently beating them with sticks until the nuts were shelled, i.e the shells were separated from seeds. The second method was done mechanically using a groundnut decorticator which crack and separate the groundnut by impact force. The machine works like hammer mill, i.e spike were welded on the center shaft, which hit the groundnut on the casing that house the shaft. This involves feeding the nuts in the hopper of the machine in batches and the shelled groundnuts with chaff were collected through the discharging chute. The heart rate, blood pressure and body temperature of each subject were measured before and immediately after each harvesting and shelling operations. These parameters are chosen because they are used to determine the energy requirements in each subject. The heart rates were determined using the stethoscope and stop watch [5]. The blood pressures of the subjects was measured using a sphygmanometer and a stethoscope with the subjects in a sitting posture and the cuff of the instrument at heart level such that the pressure values obtained were not influenced by gravity. The body temperature readings were measured by placing a clinical thermometer under the tongue of each subjects with the mouth closed. A stop watch was used to measure the time spent for each operation. The Energy Expenditure Rates, (EER expressed in kJ/min) were established from the heart rate measurements for each subject and for each task performed. The expression given [4] for energy expenditure rate is

$$EER = \frac{(HR - 66)}{2.4} \qquad \ldots\ldots\ldots\ldots 1$$

where HR is the heart rate in beats per minute. The standing and bending working postures affect the spinal extensor muscle force and the total reaction on the lumbosaceral joint experienced by the subjects. Figure 1 shows the forces acting on the lower back in a bent position as experienced during the harvesting operation.

The parameters in fig 1 are defined as:

F = Spinal extensor muscle force, SEMF,(N)
H_F = Distance between spinal extensor muscle and fulcrum (cm)
Q = Load being lifted in bending position, i.e weight of each groundnut pod harvested.(kgf)
H_q = Distance between load and fulcrum (lumbosacral joint) cm
W = Weight of the head, arms and trunk of the subject, (Kgf)
H_W =Distance between the point of action of W and the fulcrum, (cm)
Ө = Angle of fulcrum (in degrees)
Cg =Centre of gravity
R = Total reaction on the lumbosacral joint, (N).

Distances H_F and H_Q were measured using a measuring tape. H_Q was measured at the point where the subject holds the groundnut plant to uproot. Ө is the angle formed at the point the subject holds the plant for uprooting. As suggested by Levean [4], W was taken as 68.8% of the subject's body weight. Based on the resolution of these forces about the fulcrum, the spinal extensor muscle force, SEMF is given by.

$$SEMF = \frac{QH_Q + WH_W}{H_F} \qquad \ldots\ldots\ldots\ldots 2$$

While the total reaction on the lumbosacral joint is given by

$$R = \sqrt{(R_X^2 + R_Y^2)} \text{ or } (R_X^2 + R_Y^2)^{1/2} \qquad \ldots\ldots\ldots\ldots 3$$

Where R_X= Compressive force on the lumbar vertebra
R_Y= Shearing force on the sacrum

R_X and R_Y are given [4] as reaction forces about fulcrum. It is due to bending and stretching of the subject before and after uprooting. These forces were resolved based on Energy expenditure rates (EER) values, and also based on X and Y axis. The heart rates of the subjects were used to calculate the EER. The heart rate is related to the force applied during uprooting. These parameters are used to calculate the total reaction forces on the subjects during harvesting and shelling operations.

3.0 RESULTS AND DISCUSSIONS

For the harvesting operations, the heart rates of the subjects varied between 58 and 72 beats/min for harvesting method I and between 55 and 74 beats/min for method II.

The Energy Expenditure Rates (EER) determined from the heart rate measurements showed that harvesting method I has a higher average increase of 5.3 kJ/min compare to 3.7 kJ/min for method II. The field capacities of the subjects were determined for the harvesting operations using the area harvested per unit of time. The results obtained showed that harvesting method II has a higher value for field capacity of 4.4 x 10^2 m^2/h as shown in Table 5 and 6. Spinal extensor muscle force (SEMF) ranged from 2.4 to 3.3 kN and from 2.2 to 2.9 kN for harvesting methods I and II respectively. The total reaction force on the lumbosacral joint of the subjects followed a trend similar to that of the SEMF. An average value of 3.1 kN was recorded for harvesting method I against 2.7 kN for method II. Therefore, the total reactions force for both harvesting methods is lower than the NIOSH Action Limit of 3.4 kN.[4]. A t-test analysis comparing energy expenditure rate (EER), Spinal Extensor Muscles Force (SEMF), Total Reaction, and field capacity indicates that at 5% probability level, there was significant differences in the values obtained for the four variables for harvesting methods I and II. The statistical analysis showed that there are significant differences for the varieties considered for harvesting methods I and II. However, harvesting method II had relatively lower values of EER, SEMF and Total Reaction when compared with harvesting method I (Table 4). It is important to observe that for harvesting method II, work was done in a sitting posture for a greater part of the total time spent on the task, whereas in harvesting method I, work was entirely done in a bent posture. The lower values of SEMF and Total Reaction suggest that the working posture assumed in harvesting method II is better than that of method I. It can be deduced that there is a lower physiological cost of work and fatigue in harvesting method II than in method I. This may also add to the reason why method II has a higher field capacity (4.4x10^2 m^2/h) than method I (3.6 x 10^2 m^2/h). Based on these results, harvesting method II is preferred. The heart rate readings varied from 54 to 81 beats/min for manual shelling and 57 to 78 beats/min for mechanical shelling as shown in Table 2. Mechanical shelling recorded a higher average increase of EER of 5.3 kJ/min compared to manual shelling at 4.5 kJ/min. The shelling capacities were determined by the quantity of groundnut shelled per unit of time for each subject. The mechanical shelling produced a

ISSN 2347-4289

higher shelling capacity of 65 kg /h as shown in Table 5 and 6. The shelling operation recorded lower average values of SEMF in mechanical shelling (0.5 kN) compared to a higher average value for manual shelling (1.5 kN) as recorded in Table 3. It is discernable from Table 3.0 that the average values of 2.0 kN and 0.9 kN were recorded for manual and mechanical shelling respectively. However, in shelling operations, a t-test analysis comparing energy expenditure rate (EER), Spinal Extensor Muscles Force (SEMF), Total Reaction, and shelling capacity indicates that three variables, shelling capacity, SEMF and Total Reaction were significantly different for the manual and mechanical shelling methods. The increase in EER obtained for the manual shelling method was not significantly different from that obtained for mechanical shelling. For the shelling process, statistical analysis shows that there was significant difference for EER for both the manual and mechanical shelling methods. Therefore, the values obtained for the SEMF, Total Reaction and shelling capacities in for the two methods were found to differ significantly at the 5% probability level. Mechanical shelling capacity of 65 kg/h is about five times that of manual shelling of 12.0 kg/h. The spinal extensor muscle force (SEMF) for mechanical shelling (0.5 kN) was less than manual shelling (1.5 kN) by one-third. Similarly, the total reaction on the lumbosacral joint for mechanical shelling (0.9 kN) was less than that of manual shelling (2.0 kN) as shown in Table 5.
Based on these observations, it was deduced that the near standing posture assumed by farmers in mechanical shelling is better in terms of lowering the fatigue and physiological cost of work, than the sitting and bending posture under which the manual shelling was done. The increase in energy expenditure rate (EER) for mechanical shelling (5.3 kJ/min) is higher than that obtained for manual shelling (4.5 kJ/min) despite the short time spent with the mechanical Sheller. The reason for this could be that mechanical shelling involves a heavy mental load leading to a considerable increase in heart rate. Mental load in the context of information processing is accompanied by an increase in the heart rate and blood pressure [2].

4 CONCLUSIONS AND RECOMMENDATION

It can be concluded from the study that a good working posture, as assessed from spinal extensor muscle force and total reaction on the lumbosacral joint, decreases the amount of energy put into harvesting and shelling of groundnut. The statistical analysis showed that the two harvesting methods considered do not vary significantly with respect to increase in energy expenditure rate, field capacity, spinal extensor muscle force and total reaction on the lumbosacral joint. It is therefore concluded that harvesting method II with t-test of 3.33 (uprooting the groundnut plants first and later pluck the nut in a sitting position) and shelling mechanically is an appropriate combination of operations that can be adopted in groundnut production whenever a mechanical harvester is not available. This combination increases the overall performance, decreases the workload and reduces the fatigue and drudgery involved in the operations. An improvement in harvesting method II could be to uproot the groundnut plants and dry them very well (without plucking the nuts) before mechanical shelling.

REFERENCES

[1] Davidson S. (1968); The principles and practice of medicine including supplement on tropical disease. The English language book society, pp. 138 154.

[2] Ettema J. H. (1967); Arbeidsfysiologische aspecten van mentale belasting. Assen Cited from Zander; (1972) pp. 65.

[3] Hammos, R.O (1994); The Origin and History of Groundnut in Smart, J Edition The Groundnut Crop: a Scientific Basis for Improvement , Chapman and Hall, New YorkUSA.

[4] Leveau,B (1977); Biomechanics of Human Motion 2nd Edition, W.S Sauders Company, Philadelphia.

[5] Nwuba, E.I U and Kual R.N. (1986); The Effect of Working Posture in the Nigerian Hoe Farmer, J.A.E.R vol. 33 pp 179-185.

[6] Shankarappa, T., Robert, E.R and Virginia, N (2003); World Geography of Groundnut,Distribution, Production use and Trade, Available at http://www./anra.anthro.uga.edu/peanut/ nowledgedatabase(accessed April 20, 2010).

ISSN 2347-4289

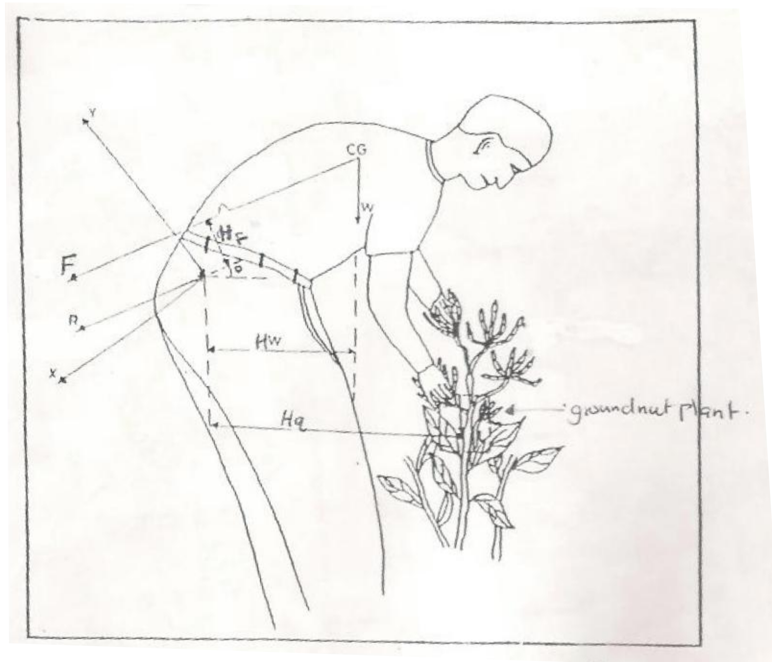

Fig 1: *Forces and distances on the lower back of a farmer harvesting groundnut pods in a bent position*

Table 1: *Description of the subjects*

Subjects	Height (m)	Body weight (kg)	Age (yrs)	Forearm length (m)
A	1.72	58.0	38	0.74
B	1.82	78.2	41	0.77
C	1.76	67.8	46	0.78
D	1.78	79.2	37	0.75
E	1.79	59.8	28	0.72
Average	1.77	58.16	38	0.75
Standard deviation	0.03	13.71	5.90	0.02

Table 2: *Heat Rate and Energy Expenditure Rate before and after Harvesting and Shelling and increase in Energy Expenditure Rate*

Operation	Heart rate (beats/min)	Energy expenditure rate kj/min	**Increased in** EER (kj/min)	Ave	Std D
	Before After A B C D E A B C D E	Before After A B C D E A B C D E	A B C D E		
Harvesting I	62 58 62 59 68 74 80 70 71 77	-1.7-3.3-1.7-2.9 0.8 3.3 5.8 1.7 2.1 4.6	5.0 9.1 3.4 5.0 3.8	5.3	2.02
Harvesting II	60 35 61 63 69 68 69 72 69 74	-2.5 -4.6 -2.1-1.31.3 0.8 1.3 2.5 1.3 3.3	3.3 5.9 4.6 2.6 2.0	3.7	1.41
Manual shelling	61 54 69 65 62 71 67 81 70 69	-2.1 -5.0 -1.3-0.4-1.7 2.1 0.4 6.3 1.71.3	4.2 5.4 7.6 2.1 3.0	4.5	1.92
Mech shelling	62 57 69 57 60 74 70 78 78 71	-0.8 -3.81.3-3.8-2.5 3.3 1.7 5.0 5.0 2.1	4.1 5.5 3.7 8.8 4.6	5.3	1.83

Avg = Average
Std D = Standard Deviation

Table 3: *Spinal Extensor Muscle Force, Shearing Force on the Sacrum, Compression Force on the Lumba Vertebra and the Total Reaction on Lumbosacral Joint for the Subjects.*

	Spinal extensor muscle force (x100 N)	Shearing forces (x I0 N)	Compression force (x I00 N)	Total reaction (x.I00 N)
	A B C D E Ave Std D	A B C D E Ave Std D	A B C D E Ave Std D	A B C D E Ave Std D
Harvesting I	3.3 2.4 2.8 2.9 3.1 2.9 0.30	4 1 -4 3 2 1.2 2.79	3.5 2.6 3.2 3.0 3.0 3.1 0.30	3.5 2.6 3.2 3.0 3.0 3.1 0.30
Harvesting II	2.4 2.2 2.6 2.7 2.9 2.6 0.24	2 2 4 1 3 2.4 1.02	2.8 2.4 2.8 2.9 2.4 2.7 0.22	2.8 2.4 2.8 2.9 2.4 2.7 0.22
Manual shelling	1.6 1.5 1.5 1.5 1.6 1.5 0.06	5 -6 -5 -6 6 -1.2 5.49	2.1 2.2 2.0 2.0 1.8 2.0 0.13	2.1 2.2 2.0 2.0 1.8 2.0 0.13
Mech shelling	0.6 0.4 0.6 0.5 0.5 0.5 0.08	3 -2 -9 -9 -3 -4.0 4.56	1.0 0.8 0.9 1.0 0.9 0.9 0.08	1.0 0.8 0.9 1.0 0.9 0.9 0.08

Avg = Average
Std D = Standard Deviation

Table 4: *Summary Results for the Field Capacity, Spinal Extensor Muscle Force, Total Reaction and increase in Energy Expenditure Rate during the Harvesting Operations.*

Operation	**Field capacity x100m^2/h)**	**SEMF (x I0 N)**	**T reaction (x I0 N)**	**Increase in EER (x I00J/min)**
	A B C D E Ave Std D	A B C D E Ave Std D	A B C D E Ave Std D	A B C D E Ave Std D
Harvesting I	40 32 34 37 36 36 2.72	33 24 28 29 31 29 3.03	35 26 32 30 30 31 2.97	50 91 34 50 38 53 20.24
Harvesting II	44 43 40 45 46 44 2.10	24 22 26 27 29 26 2.45	28 24 28 29 24 27 2.19	33 59 46 26 20 37 14.08

Avg = Average
Std D = Standard Deviation

Table 5: *The Shelling Capacity, Spinal Extensor Muscle Force, Total Reaction and increase in Energy Expenditure Rates during the Shelling Operation.*

Operation	Shelling capacity (x 100glh)	SEMF (x I0 N)	T reaction (x I0 N)	Increase in EER (x .I0 J/min)
	A B C D E Ave Std D	A B C D E Ave Std D	A B C D E Ave Std D	A B C D E Ave Std D
Manual shelling	12 14 13 12 11 12* 1.10	16 15 15 15 16 15 0.63	21 22 20 20 18 20 1.34	42 54 76 21 30 45 19.25
Mech shelling	47 74 72 59 71 65 10.26	6 4 6 5 5 5* 0.77	10 8 9 10 9 9* 0.77	41 55 37 88 46 53 18.32

Avg = Average
Std D = Standard Deviation