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ERGONOMIC EVALUATION OF MANUAL HOE FOR RIDGING AND MOUNDING OPERATIONS IN FARMING

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Abstract: Despite mechanized farming, human power is still widely used in the developing industries. The majority of the foods being consumed by Nigerians were cultivated by farmers using hoes, cutlasses and similar tools. These tools are produced locally by blacksmith without due consideration for ergonomics but as passed on to them by their trainers who in most cases are their fathers. The main aim of the study was to obtain some anthropometric data of rural farmers, identify the hoes that they used and measure the dimensions of the identified hoes. Some anthropometric data of twelve male farmers in two villages in Odeda Local Government Area of Ogun State were measured. The measured dimensions of the hoes measure were the lengths of the hoe handle, the total weight of the hoe, blade thickness, blade length, blade breadth and the angle of inclination of the blade to the hoe handle. The mean of the anthropometric data obtained were 17.8, 27.1, 108, 8.1, 8.1, 10.3 and 18.9 cm for chest depth; chest breadth, elbow height (standing), finger length, hand breadth at metacarpals, hand breadth and hand length respectively. Also, four types of hoe were identified in the villages with a mean of 2.0 kg, 2. 33 mm, 25.2cm, 24.0 cm, 34.5 mm, 50.5 cm and 45 for weight, blade thickness, blade length, blade width, handle thickness, handle length and angle inclination of the handle with the blade respectively. The study concluded that it was necessary to redesigning the hoe short-handled hoe with a view to make it long-handled to allowing for an upright and more comfortable posture during ridging or mounding operation in farming.
Keywords: Hoes; Human power; Farmers; Nigeria

1. INTRODUCTION

FAO observed that Africa remains the only continent in the developing area with consistently reduction in per Capita food production. Using the 2006 data, Agriculture contributed about 32 percent to the national GDP. Oyedemi and Olajide [1] estimated that 86 percent of the land cultivation in Nigeria is done using hoes, cutlasses and similar tools. Also, Yisa [2] stated that 80 percent of the food consumed by Nigerians is cultivated by peasant farmers. The socio-economic conditions of farmers in several developing countries including Nigeria necessitate the use of human muscle power for many farm activities.

Human power has been regarded as one of the major contributors of energy for agricultural activities in developing industries and is likely to continue for the next two decades [3]. Human energy has generally been utilised through arms, hands, and back. The import of these findings is that the majority of the foods being consumed by Nigerians were cultivated by farmers using hoes, cutlasses and similar tools. These tools are produced locally by blacksmith without due consideration for ergonomics but as passed on to them by their trainers who in most cases are their fathers.

The main aim of ergonomics is to focus on man and machine interaction [4] as any incompatibility between these two key components, within the work environment, will result in the worker experiencing physical and/or mental strain, resulting in poor performance and decreased productivity [5]. In developing countries the physical demands of the task usually exceed the physical capabilities of the worker [5]. Even in developed countries where modern mechanized agriculture has eliminated much of the manual work in many sectors, vegetable production throughout the world still involves hazardous repetitive manual labour [6]. Manual labour leads to multiple physical risk factors for musculoskeletal discomfort and injuries [6, 7].

Woodson and Berry [8] stated that human factors or ergonomics are important considerations in the development of farm machines and implements. This is due to the fact that farmers are subjected to high risks of work related injuries and as such the application of ergonomics in the design of tools and equipment is essential. Ergonomic interventions are increasingly used to reduce labour turnover rates, lower costs, increase revenue and accomplish more work with a little work force [9 -11].

Few studies have evaluated the use of hoes in developing countries [1, 12-15]. The design features of hoes have considerable implications on their performance efficiency and the health of the user as positive correlations have been established between the scooping efficiency and both the angle of inclination of the blade to the handle, and the length of the hoe handle [1]. Moreover, constant use of a short-handled hoe may result into permanent deformation of the user's spine [1]. The need for correct design of hoes with emphasis on comfort as regards the Nigerian people arises due to the fact that required anthropometric measurements are few and the local fabricators assume that manufacture of hoes is an art rather than science. The hoes are fabricated without due regard to science but as passed down from generation to generation within the family of the fabricators known in local dialect as 'Alagbede'.

The current era of user centeredness and market competition necessitates given considerations to ergonomics for agricultural equipment design as the users are no more bound to cope with whatever design imposed on them [16]. For the Nigerian population, there are very few reported anthropometric data necessary for the design of tools, equipment and products [17].

To redesign the hoes for ridging and mounding operations with due regard to comfort of the user without bending, evaluation of the existing hoes and the anthropometric data of the farmers using them are essential. The objectives of this study therefore are to:

1. Obtain some anthropometric data of rural farmers.
2. Identify the hoes that are used by farmers.
3. Measure the dimensions of the identified hoes.

2. MATERIAL AND METHOD – Study area, Subjects and Obtained Measurements

The study was carried out in two villages namely Agetu and Alagbayun in Odeda Local Government area of Ogun State, Nigeria.

The sample for the study comprised Twelve (12) male farmers without any physical disability with ages between 27 and 70 years (mean = 47.17 years, SD = 15.22 years).

The participants were given adequate information about the study and their consents were obtained before the start of the study.

Seven anthropometric dimensions were measured with the use of Vernier Calliper, Stadiometer and measuring tape. The dimensions of the hoes in use in the villages were measured. The Chest Depth, Chest Breadth, Elbow Height (Standing), Finger Length, Hand Breadth at Metacarpals, Hand Breadth and Hand Length were measured using the definitions of Institute of Industrial Engineers (Z94.2 - Anthropometry & Biomechanics: Anthropometry Section) as shown in Table 1. The measurements were taken thrice to ensure their correctness and no changes were noticed in the dimensions. The measured dimensions of the hoes measure were the lengths of the hoe handle, the total weight of the hoe, blade thickness, blade length, blade breadth and the angle of inclination of the blade to the hoe handle. The data obtained from the recorded measurements on prepared forms were combined into a file from which 5th, 10th, 50th, 90th and 95th percentiles were computed with the use of SPSS 16.0 statistical package.

Table 1. Definitions, methods of measurements and relevant applications

Body part	Definition	Method of measurement	Relevant application
Chest Breadth	the horizontal frontal distance across the chest at nipple level	the subject stands erect, breathes normally, and has the arms hanging naturally at the sides	for determining maximum lateral space available at chest level
Chest Depth	the horizontal distance from front to back of the chest at nipple level	the subject stands erect, breathes normally, and has the arms hanging naturally at the sides	For determining fore and aft space available at chest level
Elbow Height	the vertical distance from the floor to the radiale (the depression at the elbow formed where the bones of the upper arm and forearm meet)	the subject stands erect with the arms hanging naturally at the sides	relevant application is work or rest surface height, the vertical distance between the floor and table tops, e.g., desks and workbenches used in the standing position
Finger Length	the length of the right middle finger (digit 3)	the distance from the right middle finger tip to the lower crease on the palmar side (Metacarpal-phalangeal joint crease)	relevant application is the longest finger length, e.g., gloves
Hand Breadth at Metacarpal	the maximum breadth across the hand where the fingers join the palm	the right hand is extended straight and stiff with the fingers held together	relevant application is for determining the breadth available for palm, with fingers extended, e.g., handle widths
Hand Length	the distance from the wrist crease (palmar side) to the middle fingertip of the right hand extended straight on the arm	the right hand and lower arm is extended straight and stiff with the fingers held together	relevant application is for determining maximum fingertip reach from the wrist, e.g., gloves
Maximum Body Breadth	the maximum breadth across the body including the arms	the subject stands erect with arms hanging relaxed at the sides	relevant application is for determining passage clearances, e.g., door width

3. RESULTS AND DISCUSSION

The identified hoes in the villages are shown in plates 1-4. The anthropometric data for the farmers are presented in Table 1 while the dimensions of the four types of hoes identified in the villages. The anthropometric data of the farmers obtained in the present study differed from those obtained for the Indian farmers as reported by Goel et al. [18]. In fact, the dimensions of the Nigerian farmers were more in all the parameters considered than those of the Indian farmers though while 12 samples were considered in this study, Goel et al. [18[considered only 4 farmers. Four types of hoes were identified in the villages and their characteristics are shown in Table 2 and these hoes differed in terms of their characteristics which according to the farmers had to do with the capacity of the users. The mean weight of the hoe of 2.0 kg differed from an average weight of 2.5 kg obtained by [1]. An average handle length of 0.51 m obtained from the current study compared favourably with 0.55m obtained by Oyedemi and Olajide [1]. However, angle of inclination of the blades to the handles of 48^0 by Oyedemi and Olajide [1] was higher than 45^0 obtained in the current study.

Plates 1-4: The hoes identified in the villages

Table 1. Anthropometric Data of Farmers in Odeda Local Government Area of Ogun State

	5^{th} %le	10^{th} %le	50^{th} %le	70^{th} %le	95^{th} %le	99^{th} %le
Age (Years)	27.6	28.2	50	55.7	67.3	69.5
Stature (cm)	158	163	172	175	178	179
Weight (kg)	49.1	49.6	56.8	62.2	70.5	70.9
Maximum Body Breadth (cm)	37.0	38.5	42.9	43.6	46.1	47.1
Chest Depth (cm)	12.6	14.0	17.8	18.5	20.4	20.8
Chest Breadth (cm)	25.2	25.6	27.1	38.9	31.0	31.2
Elbow Height (Standing) in cm	94.9	98.0	108.0	111.4	166.3	177.3
Finger Length (cm)	7.0	7.0	8.1	8.4	8.8	8.9
Hand Breadth at Metacarpals (cm)	7.1	7.3	8.1	8.7	9.2	9.2
Hand Breadth (cm)	9.2	9.5	10.3	10.5	10.9	11.0
Hand Length (cm)	17.2	17.6	18.9	19.3	19.9	20.1

Table 2. Dimensions of Hoes

Dimension	Type 1	Type 2	Type 3	Type 4	Average	SD
Weight	2.5kg	1.9kg	1.5kg	2.0kg	2.0 kg	0.4kg
Blade Thickness	2.00 mm	2.20 mm	2.40 mm	2.70 mm	2.33 mm	0.3mm
Blade Length	26.0cm	23.4cm	22.5cm	29.0cm	25.2 cm	2.9 cm
Blade Width	26.0cm	22.0cm	22.0cm	26.0cm	24.0 cm	2.3 cm
Handle Thickness	37.0 mm	33.5 mm	32.3 mm	35.0 mm	34.5mm	2.0 mm
Handle length	52 cm	46.8 cm	45 cm	58 cm	50.5 cm	5.8 cm
Angle the handle makes with blade	45^0	50^0	45^0	40^0	45^0	4.1^0

Moreover, the average angle of inclination of the blade to the handle was noted as a possible major contributor to the relatively high energy expenditure during ridging reported in previous studies on Nigerian hoes [1]. In fact, Ismaila et al. [19] obtained the maximum energy expenditure using hoe for mounding operation as 12.92kJ/min (215.33 Watts) and concluded that there was the possibility of postural load using the hoe, which would necessitate the design of appropriate simple motorized tools for mounding operations. The use of the long-handled hoe improved efficiency according to previous studies [12, 15, 20-21]. These studies also demonstrated that a longer hoe handle reduces back pain as the workers can work in a more upright posture than with a short-handled hoe [21-22]. To reduce back pain of farm workers in the state of California (USA), the use of short-handled hoes (<1.2 m length) was banned [23]. The average length of the hoe handles in the current study showed that the hoes are short-handled and short handle hoe leads to bending and squatting which is an uncomfortable working posture. It is therefore important that the handle of the hoe should be extended which will allow for an upright and comfortable posture. Moreover, Nag and Pradhan [24] suggested that a hoe, weighing about 2 kg, having blade-handle angle of 65 to 70°, blade length 25 to 30 cm, blade width 22 to 24 cm, handle length 70 to 75 cm, and the handle diameter 3 to 4 cm may be suitable for different modes of hoeing. Using the current study, a long-handled hoe may be designed and fabricated using the following dimensions:

(i) the mean of the elbow height (Standing) of 108 cm could be used for the length of the handle.
(ii) blade length should be the mean of the blade length of the current hoes of 25.2 cm
(iii) blade width should be the mean of the blade width of the current hoes of 24.0 cm
(iv) blade thickness should be the mean of the current hoes of 2.33mm
(v) handle thickness should be the mean of the handle thickness of the current hoes of 34.5 mm
(vi) the weight of the hoe should be the mean of the weight of the current hoes of 2.0 kg
(vii) the angle of inclination of the blade to the blade should be between 65 and 70^0

CONCLUSIONS

The study concluded that there is the need to redesigning the manual hoes to make them long-handled such that standing posture could be adopted during ridging and mounding operations in farming. Moreover, the study proposes the dimensions for the redesigning of the improved manual hoe.

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