THE INTERNATIONAL JOURNAL OF SCIENCE & TECHNOLEDGE

Ergonomic Evaluation of Manual Citrus Fruit Harvester

U. S. Kankal
Department of Farm Power and Machinery, College of Agricultural Engineering and Technology
Dr. Panjabrao Deshmukh Krishi Vidhyapeeth Akola
S. M. Nage
Department of Farm Power and Machinery, College of Agricultural Engineering and Technology
Dr. Panjabrao Deshmukh Krishi Vidhyapeeth Akola
M. M. Deshmukh
Department of Farm Power and Machinery, College of Agricultural Engineering and Technology
Dr. Panjabrao Deshmukh Krishi Vidhyapeeth Akola

Abstract:
The arduous operation of harvesting is usually performed manually with use of traditional hand tools in upright posture, inducing back pain for majority of labours. In traditional method of harvesting, fruits get damage. To overcome of these problem manual citrus fruits harvester was developed at Deptt. of Farm Power and Machinery, Dr.PDKV, Akola. Ergonomical evaluation of harvester has taken in to study and found that, the average work pulse value was found to be 38 beats/min. The average oxygen consumption was found to be 0.46 lit/min. Overall discomfort rating was observed as 2.5 which comes under the category of "light" discomfort. Body part discomfort score was found to be 4.5. The work load by harvester comes under "moderate" category. The average output of the harvester was found to 2.61 kg/hr. The fabrication cost of harvester was Rs. 600/-

1. Introduction

Citrus fruits rank 3rd in area and production accounting for About 12 and 10.4 per cent (www.agricoop.nic.in) of the total area and production respectively. Lime, lemons, sweet oranges and mandarin cover bulk of the area under these fruits and are grown mainly in Maharashtra, Andhra Pradesh, Karnataka, North-Eastern States, Punjab, Orissa and Madhya Pradesh states of India.

Harvesting of limes and lemons differ with different species, varieties and region of cultivation. In most of citrus species the fruits remain for several weeks without any deterioration after attaining full maturity which facilitates harvesting according to ones choice and demand in market. In India the fruit harvest from trees manually by means tool called khudi. In such harvesting when fruits cuts from tree due thorns on trees and it directly fall on ground so fruits get damage. Hence quality of fruits is detoriated and loss a market value. Keeping the point in view, the present investigation was undertaken in study to develop manual citrus harvester. In manual operation drudgery is involved in worker. Hence ergonomics evaluation of harvester is also important. The goal ergonomics is to increase efficiency and productivity of the workers without jeopardizing there health and safety. In India , more than 200 million worker are engaged in various agricultural and allied activities, ergonomics has a very important role to play. The performance of man implement system may be poor, if ergonomics aspect are not given due attention. It may also cause clinical or anatomical disorders and will affects worker health. Proper attention to ergonomics aspects in design and operation will help increasing man implement efficiency and also in safe guarding the workers health. The increase use of machine in Indian agriculture during last decade and recent awareness generated in society about safety and occupational health aspect has made the application of ergonomics more relevant.

2. Review of Literature

On development and ergonomic evaluation of manual citrus fruit harvester the reviews of relevant work of various aspects are presented here.

Nag and Dutt (1980) mentioned that there was no consistency in heart rate response with the severity of work. This might have been due to presence of static component of loading in this activities.

Yadav and Shrivastva (1984) carried out studies on sugarcane harvesting. The increase in herat rate during work varied from 39 to 59 beat/min for different knives and energy expenditure varied from 16.25 to 24.58 KJ/min.

Kumar *et al.,* (2002) carry out ergonomic evaluation of three types weeder and found value of overall discomfort score of 4 i.e." very tired" and body part discomfort score 29.5, 26.22and 23.32 for wheat hoe, crescent hoe and Kasola, respectively.

Balanskri *et al.,* (2003) used oxygen consumption rate for ergonomic evaluation of work. This parameter was commonly used as reliable measure of physical measure

Kathirvel *et al.,* (2003) assessed body discomfort of direct paddy seeder operator and found that overall discomfort rate score was 7.67 and the corresponding discomfort scale rating was "very uncomfortable".

According to Singh and Singh (2006) estimated oxygen consumption rate was 0.511 l/min for day long work with proper rest pause Singh *et al.*, (2007) ergonomically evaluated the fruit harvester for orchard. They found the output of the harvester as 40kg/hr. The working heart rate was reported 114 beats/min and work pulse found as 35 beat/min.

3. Material and Methods

In Vidharbha region of Maharashtra the common varieties of lemon grown are Columia, Genoa, Seedless Lemon, Rough Lemon etc. These varieties were taken for study for development and evaluation of harvester. Fruit characteristics of common lemon varieties shown in following table.

Sr. No.	Variety	Avg. diameter (D), cm	Avg. height, H cm	Average D/H index
1	Columia	6.64	7.11	0.598
2	Genoa	7.11	9.19	0.771
3	Seedless Lemon	6.8	9.29	0.746
4	Rough Lemon	7.00	7.43	0.943

Table 1: Fruit characteristics of common lemon varieties

The data presented above table reveal that Genoa produced the highest average diameter of 7.11 cm and average height 9-19 cm. Generally lemon trees reach up to height of 7.62 m at maturity. The above fruit characters were mainly considered for design of manual citrus harvester. The manual citrus fruit harvester was designed and developed at Department of Farm Power and Machinery, Dr. PDKV, Akola. Prototype harvester is consisting of mainly main body, cutting mechanism, collection device.

Main body: Small bucket of bucket elevator of 12x8.5 cm size was used as a main body on the basis of fruits sizes. Cutting Mechanism: The cutting blade is fixed at upper side of bucket at an angle of 65 degree scissor type blade is used to consisting of a pair of arms hinged at central point providing sufficient space for cutting edge and handling portion. The scissor is operated by gear clutch through cable attached to M.S. pipe of size 2.5 cm diameter and 225 cm length. The cutting mechanism is shown in plate 1. It shows that main body and cutting mechanism of manual citrus fruit harvester. Collection device: The PVC pipe of 5cm diameter and 210 cm length is provided for deliver lemon after cutting. The lemon are finally collected in the net provided at the lower end of PVC pipe. The design of various parts of lemon harvester are shown in fig. 1. Prototype manual citrus fruit harvester are shown in plate 2. The details specification and fabrication cost citrus fruits harvester are presented in table 2.

S. N.	Particular	Size/specification	Quantity	Rate. (Rs)	Total cost, Rs.
1	PVC pipe	Dia. 5cm with length 255 cm	255 cm	8/30cm	68/-
2	MS pipe	2.5 cm length 195 cm	195 cm	21.50/30 cm	140/-
3	Bucket	12x8.5cm	1 No	22/no	22/-
4	Scissor	---	1 No	40	40/-
5	Gear clutch	---	1 No	50	50/-
6	Cable with housing	---	--	--	40/-
7	Net	30x30 cm	1 No	--	30/-
8	Reducer	6.3x5 cm	1 No	35/-	35/-
9	Spring	---	1 No	--	10/-
10	Nut and bolt	---	4 No	--	10/-
11	Rivet	Length 3 cm and 0.3 cm thick	2 No	--	05/-
12	Labour charge				150/-
Total, Rs.					600/-

Table 2: The details specification and fabrication cost citrus fruits harvester

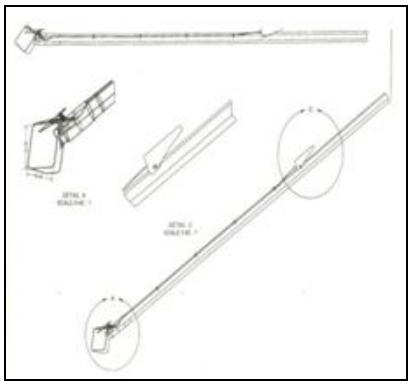

Figure 1: Auto CAD design of manual citrus fruit harvester
Plate 1: Cutting mechanism of manual citrus fruit harvester
Plate 2: Manual citrus fruit harvester in operation

3.1. Field Harvesting

Field trials of manual citrus fruit harvester were taken at citrus dieback, Central Research Station, Dr. PDKV, Akola. Field performance of fruit harvester includes testing of harvester for tits output capacity and ergonomic evaluation. The ergonomics evaluation includes measurement of heart rate, oxygen consumption rate, overall discomfort and body part discomfort. Four subjects were taken for trials. Their age, weight and height were recorded which is presented in table 3.

Sr. No.	Name of subject	Age, year	Weight, Kg	Height, cm
1	Suman	43	53	153
2	Vandana	39	57	156
3	Rajani	40	53	149
4	Gokarna	42	49	155

Table 3: Observations related to the subjects

3.2. Measurement Of Heart Rate During Operation

Heart rate of the subject was measured during harvesting of lemon at various time interval. Heart rate is a sensitive and fine discriminating measure for evaluating strain in muscular work. Heart rate can be measured and analyzed easily in practice without disturbance to the worker by using heart rate monitor. The heart rate has been referred to as the primary indicator of the strain or the physiological reaction of a specific person to the stress of environment (Brouha, 1967). Heart rate is the number of ventricular beats taken by the subjects per minute.

For measurement of heart rate polar heart rate monitor was used which is shown plate 3. It consist of a chest belt and wrist receiver. Before start of the operation all precaution were observed while fitting the heart rate monitor as mentioned by manufacturer. The watch of the monitor was fitted to the wrist of the subject. The chest belt having inbuilt electrodes was fitted on her chest. Before starting experiment the subject given a rest 30 min. The dry bulb temperature, wet bulb temperature and relative humidity were measured during each day. From the heart rate values of oxygen consumption is calculated. After the completion of trials, the subject were asked to take rest for period until their heart rate and body discomfort reached the resting level. Oxygen uptake is an expressing of the rate of energy output or rate of work (Rodal 1989). Oxygen consumption values were also calculated. Physiological cost of operation is expressed in terms of heart rate and oxygen consumption rate is the correct variable for measuring physiological work load but it is difficult to measure while performing task hence, indirect method i. e. Estimation of oxygen consumption using correlation between heart rate and oxygen consumption is used. Different equation are available to correlate heart an oxygen consumption rate. However in the present study the following equation proposed by anonymous (2007) was used.

$Y = 0.0162X - 1.314$

Where, Y = Oxygen consumption rate, lit/min

X = Heart rate in beats/ min

The physical work load of the subjects after harvesting operation was categorized on the basis of heart rate values.

3.3. Measurement Of Discomfort

It include discomfort and body part discomfort. Discomfort is the body pain arising as a result of the working posture and excessive stress on muscles due to the effort involved in activity. It is also called overall discomfort. In many agricultural operations, through the work may be within physiological limits, the body discomfort restricts the duration of work depending upon the static loading component involved in it. Drudgery caused due to bad posture is reflected in terms of postural discomfort experienced by worker. It has been observed by Gite (1996) that the muscular discomfort of the body is comparatively more important than heart rate and oxygen consumption rate in agricultural operations as limiting factors. For assessment of body discomfort, various subjective rating scales having have been developed, but the scale that are commonly used are those of Corllet and Bishop (1976) and Visual Analog Discomfort (VAD) scale proposed by Leg and Mahanthy (1985). In the present study two method i.e. Overall Discomfort Rating (ODR) and body part discomfort.

For the assessment of overall discomfort rating a 10 pint visual analogue discomfort (VAD) scale proposed by Leg and Mahanthy (1985) was used (fig.2). A 70 cm scale was used having 10 equidistantly parts, representing 0 No discomfort at extreme left side and 10 extreme discomfort at extreme right side. A movable pointer was provided on the scale to indicate the rating. At the end of each trial subjects were asked to indicate their overall discomfort rating. Overall discomfort rating given by each of the subjects were added and averaged to get the mean rating.

To measure body part discomfort score Corlett and Bishop (1976) technique was used. This technique the subjects body is divided in to 27 regions. For evaluating body part discomfort score, a figure having different numbered body part as shown fig.3 was presented in front of the subject. The subjects was asked to maintain all body parts with discomfort starting with most painful, the next most painful and so on till no further areas were reported. The number of different groups of the body parts, which were identified, from extreme discomfort to no discomfort represented the number of intensity levels of pain experienced. The rate was assigned to those categories in an arithmetic order, viz 1st category (body parts experiencing maximum pain)rating was allotted as "3" and for 2nd category (body arts experiencing next maximum pain)rating was allotted as 2 and finally for 3rd category (body parts experiencing least pain) rating was allotted as 1. It was found that the number of intensity level of pain experienced by different subjects might vary. The discomfort score of all the subjects were added and averaged to get mean score.

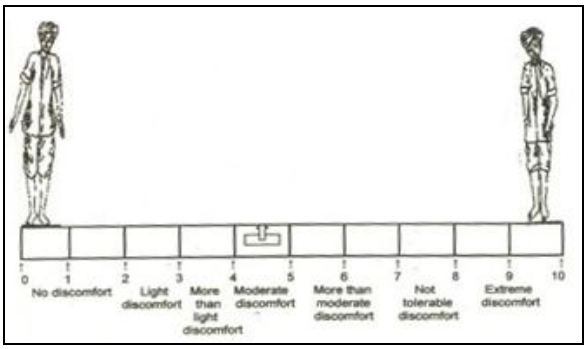

Plate 3. Polar heart rate monitor

Figure 2: Visual analog discomfort (VMD) scale for assessment overall dody discomfort rating

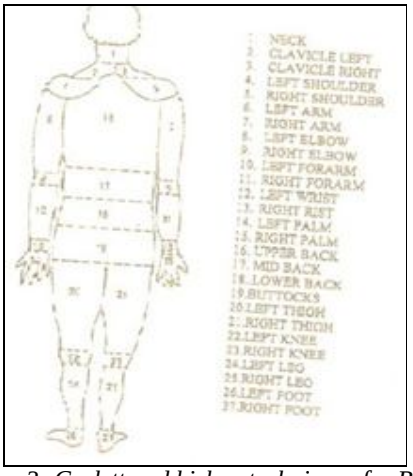

Figure 3: Corlett and bishop techniques for BPDS

4. Result and Discussin

For ergonomic study point of view ages of subjects were selected in the range of 39 to 43 year, height was 149 to 156 cm and weight was 49 to 57 kg for harvesting operation by using prototype harvester.

4.1. Measurement Of Heart Rate And Oxygen Consumption Rate

In ergonomic evaluation of manual fruit harvester following physiological parameters of subjects has been measured which are presented in tables 4. From table 4 it is seen that, the average working heart rate was observed as 109.5 beats/min the increase in heart rate over rest (work pulse) was observed as 38 beats/min. The environmental parameters such as temperature, humidity and sun shine are also responsible for higher rate. By considering the heart rate values the load was categorized and it comes under moderate category. From table 5 it is seen that ,the average oxygen consumption value was 0.46 lit/min.

SN	Name of subject	Resting heart rate, (beats/min)	Time interval, (min)							Work pulse (beats/min)
			10	20	30	40	50	60	Avg.	
			Working heart rate, (beats/min)							
1	Suman	75	108	110	113	117	119	123	115	40
2	Vandana	76	106	109	113	115	117	118	113	37
3	Rajni	70	102	104	105	108	113	112	107	37
4	Gokarna	75	108	101	102	103	105	109	113	38
Average									109.5	38

Table 4: Measurement of heart rate

SN	Subject	Time interval, min						
		10	20	30	40	50	60	Average
		Oxygen consumption, (lit/min)						
1	Suman	0.43	0.46	0.51	0.58	0.61	0.67	0.54
2	Vandana	0.40	0.45	0.51	0.54	0.58	0.59	0.51
3	Rajni	0.33	0.37	0.38	0.43	0.51	0.50	0.42
4	Gokarna	0.27	0.32	0.33	0.35	0.38	0.54	0.35
Average								0.46

Table 5: Measurement of oxygen consumption rate

4.2. Overall Discomfort Rate (ODR)

The observations regarding the overall discomfort value are given in table 6. From table 6 it shows that mean rating of overall discomfort was found to be 2.5 which comes under the category of light discomfort.

SN	Name of subject	Overall discomfort rating	Mean rating
1	Suman	2	2.5
2	Vandana	3	
3	Rajni	3	
4	Gokarna	2	

Table 6: Overall discomfort rating of the subjects

4.3. Body Part Discomfort Scale

As the weight of manual citrus fruit harvester is only 3 kg it is easily handled by female worker. No serves discomfort was observed in any body part of the subject slight pain was observed in neck back and forehand of subjects. The observation regarding the body part discomfort score are given in table 7.

SN	Name of subject	Overall discomfort rating	Mean rating
1	Suman	5	4.5
2	Vandana	4	
3	Rajni	4	
4	Gokarna	5	

Table 7: Body part discomfort score subjects

From the table 7 it is seen that the average body part discomfort score found to be 4.5.

4.4. Output Capacity

The observation regarding the output capacity of citrus fruit harvester are given in table 8. The average output of the citrus harvester was found to be 2. 61 kg/hr

Sr. No.	Name of subject	Avg. fruit harvester, kg/hr
1	Suman	2.59
2	Vandana	2.48
3	Rajni	2.75
4	Gokarna	2.64

. Table 8: Output capacity of the citrus fruit harvester

5. Conclusion

The conclusions drawn from the result obtained are summarized as below

- The average work pulse value was found to be 38 beats/min.
- The average oxygen consumption was found to be 0.46 lit/min.
- Overall discomfort rating was observed as 2.5 which comes under the category of “light” discomfort.

- Body part discomfort score was found to be 4.5.
- The work load by harvester comes under “moderate” category.
- The average output of the harvester was found to 2.61 kg/hr.
- The fabrication cost of harvester was Rs. 600/-

6. Referances

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