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Development and performance evaluation of motorized groundnut stripper

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Abstract

Groundnut production involves numerous farm activities from dibbling, harvesting, decortication to value addition. The farm women play a significant role in all these activities. Majority of these activities are performed solely by women. Among these, stripping is an important post-harvest activity in which women are involved as the major labour force. It is laborious and time consuming and farm women are facing many health problems *viz.*, body pain and blackening of palms. The experiment revealed that weeding, stripping and decortication as drudgery prone activities. Improved/motorized tools for weeding and decortications have been developed and intervened to hasten the activity. Similarly, manually operated strippers have been developed and tested to reduce the drudgery of farm women. Even then farmers are facing difficulty due to shortage of laboures and also due to high labour wages. Hence, to reduce the drudgery while performing groundnut stripping activity, All India Coordinated Research Project-Home Science-Family Resource Management component of UAS, Dharwadhas developed motorized groundnut stripper and evaluated it at the field level. Thirty non-pregnant farm women with normal health, and without any major illness or cardio-vascular problems, falling in the age range of 25-45 years were selected for the study. The results showed that the machine was safe and easy to operate. It also proved the excellence in work output with an average stripping rate of 50 kg per hour as compared with other models and traditional method of hand stripping (10.50 kg/hour). The farm women perceived using groundnut stripping machine made the work simple and light. They also experienced less drudgery as compared to traditional hand stripping. Hence, such small improved and mechanized farm tools can be promoted among small and marginal farmersto reduce the drudgery and save the labour cost.

Keywords: Drudgery, groundnut stripper, rate of perceived exertion, stripping, work out put

Introduction

Groundnut is a major oilseed contributing significantly to the Indian economy. Groundnut production has been increasing steadily in Karnataka state over the last few years. Groundnut production includes the activities from seed to plate like dibbling, stripping, decortications and value addition. Among all these activities, harvest and post-harvest activities of groundnut are laborious and time consuming. These activities include uprooting, bundling / bunching and pod plucking / stripping. All these activities are performed manually in traditional method. Recently manually operated improved agricultural tools like decorticator and strippers have been introduced and found to be efficient. Rodla *et al.* (2019) [10] found that the adoption of drudgery reducing agricultural technologies developed for farm women has seen increase in their work output and reduced the drudgery. Hence it can be concluded that the reduced drudgery and time while using the improved technologies has fetched postural comforts in farm women. It also has increased their income and in turn improved farm women's livelihood and health.

The review of literature as well as the research work carried out at All India Coordinated Research Project on Family Resource Management reveled that efforts have been made to reduce drudgery of farm women while performing weeding and groundnut decortication activities by developing and introducing improved /motorized tools. The requirement of more number of workers will be eliminated as only one worker can carry out the complete threshing operation with use of battery operated groundnut stripper (R. S. Yadav *et al*., 2018) [9]. In the present study an effort has been made to reduce the drudgery of farm women while stripping. The traditional manner of groundnut stripping is usually done by twisting and pulling the pods from vines. In some regions, the harvested vines are beaten with wooden sticks. Both the traditional methods are tedious and can cause injuries to the fingers of farm women.

They also damage the nuts. Manually operated strippers are developed and tested to reduce the drudgery of farm women. Still farmers are facing difficulty due to shortage of labourers and high labour wages. Hence, with an objective to reduce the drudgery of performing this activity, to hasten the work and to reduce the labour cost, motorized groundnut stripper was designed and developed by AICRP-HSc.- Family Resource management, UAS, Dharwad. The performance evaluation of the developed groundnut decorticator was tested, ergonomically analysed and the results are discussed in the present study.

Methodology
The study was conducted in two stages
1. **Survey:** The survey was conducted to study the participation level of farm women in ground nut production system. Self structured questionnaire with interview method was used to collect the data. The village of Dharwad taluk of Karnataka state *viz*., Narendra, Yadawad and Mulamuttala villages were selected for the study. Sample study involved thirty women in groundnut production system. Based on the survey results, further experiment was carried out.
2. **Experiment:** The performance evaluation of the groundnut decorticator was carried out at AICRP- Oil seed, MARS, UAS, Dharwad of Karnataka state in India. Thirty non-pregnant women with normal health, without any major illness or cardio-vascular problems, falling in the age range of 25-45 years were selected for the study. Care was taken to select the farm women who perform the groundnut stripping activity regularly.

The variables and their measurements are discussed in detail as below.
Gender participation: Gender participation was analyzed by using the following five point scale *viz*., WE - Women exclusive only: 1, WD - Women dominated and supported by men: 2, ME - Men Exclusive only: 3, MD - Men dominated and supported by women: 4, EP- Equal participation by men and women: 5.

Physical characteristics of the respondents: Measurement of physical characteristics namely, age, height and weight of each respondent were recorded before starting the experiment. The body mass index, body type and aerobic capacity were estimated to assess the health condition and physical fitness of the women selected for the study as detailed below.

Body type: The respondents were classified into different body types based on the Quenelles Body Mass Index classification.

Body Mass Index (BMI): The Body Mass Index is determined based on body height and weight by using the formula and were further classified based on the James *et al*., BMI classification (1988) classification table.

$$BMI\ (kg/m^2) = \frac{Weight\,(kg)}{Height^2\,(m)}$$

Aerobic capacity method (VO$_2$max): The aerobic capacity is also another indicator of the physical fitness of the subjects. The consumption of maximum volume of oxygen (VO$_2$ max) was estimated based on the body weight and height of the

respondents. The respondents were classified into various physical fitness categories according to the classification given by Saha (1996). VO$_2$ max (l/min) =0.023 x Body weight (kgs)-0.034 x Age (years) + 1.652.

$$VO_2\ max\ (ml/kg.\ min) = \frac{VO_2\ max\ (l/min)}{Body\ weight} X\ 1000$$

Repetitive strain or exertion faced by the farm women was assessed with the use of Job Strain Index. The JSI is assessed by using five parameters *viz*., Intensity of Exertion, Duration of Exertion, Efforts per Minute, Hand/Wrist Posture, Speed of Work, Duration of Task Per Day. It evaluates the risk of work related Muscular Skeletal Disorder of the Distal upper extremities (Wrist, hand and elbow).

Workplace Ergonomic Risk Assessment (WERA) was used to assess: Work-related Musculoskeletal Disorders. It is an observational tool was developed to provide a method of screening the working task quickly for exposure physical risk factor associated with Work-related Musculoskeletal Disorders (WMSDs). The WERA tool covers the six physical risk factors including posture, repetition, forceful, vibration, contact stress and task duration and it involves five main body regions (shoulder, wrist, back, neck and leg). It has a scoring system and action levels which provide a guide to the level of risk and need for action to conduct more detailed assessments. Corlet & Bishop's body map was used to locate pain by the respondents for Musculo skeletal Disorder and discomfort rating (Very severe-5, Severe-4, Moderate-3, mild-2, very mild-1). The pains and disorders were recorded as per the body part and symptoms and disorder experienced. The rating of pain was given on a five point scale.
Rapid Upper Limb Assessment and Rapid Entire Body Assessment tools were used to assess the musculo skeletal disorders.
Rapid Upper Limb Assessment (RULA) was developed to "rapidly" evaluate the exposure of individual workers to ergonomic risk factors associated with upper extremity MSD by Dr. Alan Hedge (1993) [1]. The RULA ergonomic assessment tool considers biomechanical and postural load requirements of job tasks/demands on the neck, trunk and upper extremities.
REBA work sheet/ Rapid Entire Body Assessment sheet score represents the level of MSD risk. It is a systematic process to evaluate MSDs of whole body (wrists, fore arms, elbows, shoulders, neck, trunk, back, legs and knees) and the risk associated with the work on the basis of observation, using the REBA work sheet.
Perceived exertion was assessed by using Varghese *et al.* (1995) [12] five point scale.
Drudgery experienced by farm women was assessed by the seven parameters, namely work demand, feeling of exhaustion, posture assumed in work, manual load operative, difficulty perception, work load perception and human power used by using different scales as detailed below.
a. **Work Demand (Score 1-5):** Very demanding (5), demanding (4), moderate (3), less demanding (2), Very less demanding (1)
b. **Feeling of Exhaustion (Score 1-5):** Very exhausted (5), exhausted (4), moderately exhausted (3),Mildly exhausted (2), No exhaustion (1)
c. **Posture assumed in work (Score 1-5):** Very difficult (5), difficult (4), moderately difficult (3). Easy (2), very

easy (1)

d. **Manual Load Operative (Score 1- 5):** Very heavy loads (5), heavy loads (4), moderately heavy loads (3), light loads (2), no loads (1).

e. **Difficulty perception (Score 1- 5):** Very painful (5), painful (4), moderately painful (3), mild pain (2), no pain (1)

f. **Work load perception (Score 1- 5):** Very heavy (5), heavy (4), moderately heavy (3), light (2), very light (1)

g. **Human power used (Score 1- 5):** Very heavy (5), heavy (4), moderately heavy (3), light (2), very light (1)

Assessment of Drudgery Index

The average scores of above selected six parameters *viz*., rating on work demand, rating on felling on exhaustion, rating on posture assumed in work, rating on manual loads operatives, rating on work load perception, rating on difficulty perception were added to calculate the drudgery index

Results and Discussion

Table 1 presents the details of gender participation and technology usage in Groundnut production system. The activities *viz*., weeding, stripping and decortication were women exclusive activities. Sowing and uprooting were observed to be men exclusive activities, while inter cultivation and fertilizer application were performed by both men and women. These activities were observed to be performed in traditional manner by using traditional technologies.

The drudgery experienced while performing women exclusive activities *viz*., weeding, stripping and decortication were studied by considering the different drudgery parameters and by assessing the drudgery index and the results are depicted in the Table 2. The drudgery scores of weeding (DS: 24.33), stripping (DS: 24.06) and decortication activities (DS: 24.36) revealed that all these were considered as drudgery prone by the farm women.

Hence, from the above results it was studied that weeding, stripping and decortication activities were women exclusive. Incase of weeding and stripping activities, efforts have been made to design and develop improved tools/technologies. In the present study emphasis was given to reduce the drudgery while performing stripping activity.

An effort was made to hasten the stripping work and to reduce the labour cost. Hence, motorized of groundnut stripper was designed and developed by AICRP-HSc.- Family Resource management, UAS, Dharwad. The features are discussed as below.

The stripper runs with the help of an electrical motor of single phase, 0.5 hp. The cylindrical type of machine is closed on all the sides with two openings, one for feeding channel, the other one for pod collection.

- Suitable for groundnut stripping (of three seed pod) immediately after harvesting.
- Can be operated by two persons simultaneously and it is gender friendly.
- Has a square tube frame with 10mm teeth
- Has two Pullies with V belt
- Pedal operated on / off switch
- Machine weight 55 kg, width: 2", Height: 3"
- As a safety measure, teeth have a mesh of width: 2'.7", teeth width: 1'.6".

The performance evaluation of the developed groundnut decorticator was tested, ergonomically analysed and discussed.

The physical characteristics of the subjects: The physical characteristics of the subjects selected for the ergonomic analysis of groundnut stripper activity are presented in Table 3. The mean age of the farm women was 37.36 years with the mean height of 151.76 cms and mean weight of 54.60 kgs. The estimated mean aerobic capacity based on height and weight was 30.32 ml/kg. min and the mean Body Mass Index of selected farm women was 23.71, revealing the fact that majority of them fell in normal category of Body Mass Index. The distribution of the respondents based on the physiological parameters like body type, Body Mass Index and aerobic capacity are presented in Table 4. Maximum per cent age of farm women (46.66%) had Mesomorph body type, only ten per cent women had ectomorph body type as per the Quetlets Index.

The physical fitness grading according to Body Mass Index classification revealed that nearly half of the sample (43.33%) belonged to Normal Body Mass Index, ranging between 20-25 per cent followed by 40 per cent (Obese Grade-I). Thirteen per cent of the farm women fell in the Low Weight Normal grades.

According to the estimated aerobic capacity of the selected respondents based on body height and body weight, more than half of the sample (56.66 %) were in the good range followed by high average category (36.66 %) and equal per cent of respondents (3.33 %) were in the Low average and Very good of oxygen consumption i.e Vo2 Max (l/min.) category.

Table 5 revealed the repetitive strain or exertion faced by women while performing groundnut stripping activity in existing and improved methods. The JSI score for left and right hand were 3.25 and 18.00 respectively while performing the activity in existing method indicating that job may place individual at increased risk for distal upper extremity disorders and Job is probably hazardous for right hand. The intervention of the motorised groundnut stripper reduced the repetitive strain or exertion faced by the farm women. The JSI scores for the improved method indicated that the job of groundnut stripping is probably safe.

Workplace Ergonomic Risk Assessment done for both existing and improved methods. The WERA score for existing method was higher (WERA score: 31) indicated medium level of risk as compared to improved method (WERA score: 26). The risk of performing the stripping activity was reduced considerably by the intervention of the motorized ground nut stripper (Table 6).

Table 7 revealed the discomfort and body pain rating by farm women were recorded after performing groundnut stripping activity in existing and improved methods. The maximum body pain rating in shoulder (3.75) was observed followed by knee and waist (3.50) lower back (3.15), and fingers (3.00). The discomfort and body pain ratings were reduced drastically after performing the striping activity using motorized activity. The Sum of discomfort rating (24.10) and average pain rating (3.01) were comparatively high after performing groundnut stripping in existing method as compared to improved method (12.48 and 1.78 respectively).

The farm women percieved less exertion with the use of electrical bamboo cutting machine (RPE: 1.80)as compared to traditional method (RPE: 3.10)

The REBA and Rapid Upper Limb Assessment (RULA) were applied to evaluate the exposure of individual workers to ergonomic risk factors associated MSD for existing and improved method respectively. The REBA score for existing method (06) indicated further investigation, while the RULA score for improved method indicated further investigation and change may be needed. The comparison of REBA and RULA scores indicated that the improved method has reduced the risk of MSD considerably (Table 8).

Drudgery experiences of farm women while performing groundnut stripping activity by different types of strippers (CIAE Bhopal, KVK UAS Dharwad, and Udaipur model) and conventional method are shown in Table 9. The results revealed that the different drudgery parameters were scored lesser after performing the stripping the activity using motorized groundnut stripper as compared to traditional and other three methods of performing the activity. The comparison of performance evaluation of strippers with traditional method and other two method of groundnut stripping is presented in Table 10. The work efficiency with the use of motorised groundnut stripper was considerably higher (50kg/ hour) than the conventional method (4.26 kg/ hour). The use of the motorised groundnut stripper reduced the labour requirement and wages drastically.

Further, the results revealed that the output capacity with the developed groundnut stripper was higher (44 kg/hour) than the traditional method (10.50 kg/hour). Further the results revealed that one labour is required for stripping one quintal groundnut by motorized stripper as compared to 8 persons by traditional method. Thus motorized groundnut stripper proved excellence in output capacity in comparison traditional method and in turn reduced the labour wages and number of labourers needed to a greater extent. The economic benefit by using motorized stripper was highest among all other methods Rs.854/- as compared to traditional method.

The farm women perceived less exertion and drudgery while working with motorized groundnut stripper (RPE: 2.00 & DS: 21.30) as compared to traditional method (RPE:3.50 & DS: 18.36).

The results of the study were compared with the data of AICRP-FRM Annual Report and the results performance evaluation of pedal operated groundnut pod stripping machine which showed that the machine was safe and easy to operate with an average stripping rate with 3 persons was 25 kg per hour Ghatge et al. (2014) [5]. The results the study conducted by Ashok. S. Andhale et al. (2017) [2] revealed that groundnut separator machine will help to improve the threshing efficiency of small farmers where electricity is not available. It will also help to reduce both threshing cost and threshing time. It was found that motorized groundnut stripper more efficient as compared to all types of groundnut strippers and all other parameters.

Table 1: Gender Participation and technology usage in Groundnut production system

N=30

Sl.no.	Activity	Frequency	Gender participation					Technology usage
			WE	WD	ME	MD	EP	
1	Sowing	30	-	-	30 (100.00)	-	-	Manual
2	Intercultivation and Fertilizer application	30	-	-	-	-	30 (100.00)	Manual
3	Weeding	30	30 (100.00)	-	-	-	-	Kurupi
4	Uprooting	30	-	-	30 (100.00)	-	-	Manual
5	Pod Plucking/Stripping	30	30 (100.00)	-	-	-	-	Manual
6	Decortication	30	30 (100.00)	-	-	-	-	Manual

WE: Women Exclusive, WD: Women Dominating, ME: Men Exclusive,
MD: Men Dominating, EP: Equal participation
* Note: Figures in Parenthesis indicate Percent

Table 2: Comparison of drudgery experience by women while performing under Groundnut production system

N=30

Sl. No	Drudgery factors	Groundnut production system		
		Weeding	Stripping/pod plucking	Decortication
1	Work demand	3.00	3.00	3.50
2	Feeling of exhaustion	2.83	2.95	3.00
3	Posture assumed in work	3.10	2.83	3.50
4	Perception on manual work load	3.00	3.00	2.60
5	Difficulty perception	3.00	3.50	2.50
6	Work load perception	3.20	2.98	3.16
7	Rating of Perceived Exertion	3.00	3.00	3.10
8	Human power used	3.20	2.80	3.00
	Total Drudgery Score	24.33	24.06	24.36
	Average drudgery score	3.40	3.00	3.04

Table 3: Physical characteristics of the subjects selected for groundnut stripper

N=10

Sl. No	Physical Characteristics	Mean	Standard Deviation
1	Age (years)	37.36	± 6.94
2	Height (cms)	151.76	± 1.95
3	Weight (kgs)	54.60	± 7.21
4	Body Mass Index	23.71	± 3.19
5	Aerobic Capacity (ml/kg x min)	30.32	± 4.72

Table 4: Distribution of the respondents selected for groundnut stripper experiment according to their physical parameters

N=10

Sl no.	Parameters	Age (30-51 years)	
		Frequency	Per cent age
I	**Body Type**		
1	Ectomorph	03	10.00
2	Mesomorph	14	46.66
3	Endomorph	13	43.33
II	**Body Mass Index**		
1	CED Grade III (Severe) (<16.0)	-	-
2	CED Grade II (Moderate) (16.0-17.0)	-	-
3	CED Grade I (Mild) (17.0-18.5)	-	-
4	Low Weight Normal (18.5-20.0)	04	13.33
5	Normal (20.0-25.0)	13	43.33
6	Obese Grade-I (25.0-30.0)	12	40.00
7	Obese Grade-II (>30.0)	01	3.33
III	**Aerobic capacity method (VO₂ max)**		
1	Poor	-	-
2	Low average	01	3.33
3	High average	11	36.66
4	Good	17	56.66
5	Very good	01	3.33
6	Excellent	-	-

Table 5: Repetitive strain or exertion faced by women while performing groundnut stripping activity in existing and improved methods

N=10

JSI score	Particulars / Remarks	Existing		Improved	
		Left hand	Right hand	Left hand	Right hand
SI≤3	Job is probably safe	-	-	0.75	1.50
3<SI<7	Job may place individual at increased risk for distal upper extremity disorders	3.25	-	-	-
7<SI	Job is probably hazardous	-	18.00	-	-

Table 6: Workplace Ergonomic Risk Assessment (WERA) of women while performing groundnut stripping activity in existing and improved methods

N=10

Sl no.	Risk level	WERA Score	
		Existing method	Improved method
1	Low	-	26
2	Medium	31	-
3	High	-	-

Table 7: Body part involved along with discomfort rating while performing groundnut stripper

N=10

Sl. No.	*Body part involved while working groundnut stripper	Discomfort rating	
		Existing	Motorized
1	Shoulder	3.75	2.25
2	Waist	3.50	2.50
3	Lower back	3.15	1.20
4	Upper legs	2.93	2.03
5	Knee	3.50	2.00
6	Hands	2.87	2.00
7	Finger	3.00	2.00
	Sum of discomfort rating	24.10	12.48
	Average pain rating	3.01	1.78
	Rate of Perceived Exertion	3.10	1.80

Table 8: RULA and REBA scores for existing and improved methods of Groundnut stripping activity

N=10

Activity	REBA scores and Remark	
	Existing method	Improved method
Stripping activity	06 Further investigation, change soon	03 Further investigation, change may be needed

Table 9: Drudgery experiences compared while Stripping of Groundnut by different types of strippers with conventional method

N=10

Drudgery Parameters	Traditional Method	CIAE* Improved	KVK Model* Improved	Udaipur model* Improved	Motorized Stripper Improved
Rating on work Demand (Score 1-5)	3.75	2.20	2.45	3.1	2.10
Rating on Feeling of Exhaustion (Score 1-5)	3.70	3.40	4.05	3.4	2.90
Rating on Posture assumed in work (Score 1-5)	2.80	3.15	3.00	3.45	2.77
Rating on Manual Loads Operatives (Score 1- 5)	2.85	3.70	3.80	2.9	2.75
Rating on Difficulty perception (Score 1-5)	2.70	3.55	4.05	3.15	2.63
Rating on work Load Perception (Score 1-5)	2.55	3.30	3.50	2.95	2.41
Rating of Perceived Exertion (Score 1-5)	3.50	3.25	3.20	2.50	2.00
Human power used (Score 1-5)	2.95	3.9	3.4	3.05	2.80
Total Score	21.30	23.20	24.70	22.00	18.36

*Data of AICRP-FRM Annual Report 2014
1. Very demanding (5), demanding (4), moderate (3), less demanding (2), Very less demanding (1)
2. Very exhausted (5), exhausted (4), moderately exhausted (3), mildly exhausted (2), No exhaustion (1)
3. Very difficult (5), difficult (4), moderately difficult (3). Easy (2), very easy (1)
4. Very painful (5), painful (4), moderately painful (3), mild pain (2), no pain (1)
5. Very heavy loads (5), heavy loads (4), moderately heavy loads (3), light loads (2), no loads (1).
6. Very heavy (5), heavy (4), moderately heavy (3), light (2), very light (1)
7. Very heavy (5), heavy (4), moderately heavy (3), light (2), very light (1)
8. Very heavy (5), heavy (4), moderately heavy (3), light (2), very light (1)

Table 10: Performance evaluation of different types of Groundnut Strippers with conventional method

Parameters	Traditional (minutes)	KVK Model* Improved	CIAE Model* Improved	Udaipur Model * Improved	Motorized Stripper Improved
Output capacity (kg/ hour)	10.50	17.79	14.19	4.26	44
Drudgery Score (30 max)	21.30	23.20	24.70	22.00	18.36
Labour requirement/ Quintal	2.93	0.7 0	0.88	2.93	0.25
Labour wages (Rs / Quintal)	933.10 /-	223.44 /-	280.13 /-	933.10 /-	79.50 /-
Economic Benefit (Rs/ Quintal)	0.00	709.66/-	652.97/-	0.00	853.60/-

Labour charges: @Rs.318/- per day
*Data of AICRP-FRM Annual Report 2014

Conclusion
The ergnomic analysis of motorised groundnut stripper through Job Strain Index, Workplace Ergonomic Risk Assessment, REBA and RULA tools and perceived exertion revealed that Motorized groundnut stripper reduces the drudgery, MSD and postural discomfort and increased the work output/ efficiency as compared to traditional method. Further it proved excellence in work done / work output in comparison traditional method and in turn reduced the labour wages and number of labourers needed to a greater extent. The percentage of pod damage was less.
Hence, it is recommended for small and marginal farmers to reduce the drudgery and save the labour cost.

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