Ergonomics Assessment of Post Harvest Finger Millet Threshing for reducing Women Drudgery

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ABSTRACT

In hills, the processing of small millets is mainly done by women. The drudgery involved in manual processing of small millets is an important reason of reduction in consumption of small millets. The small seed size also makes processing of these crops difficult and time consuming. To overcome this problem, an efficient finger millet and barnyard millet thresher named as Vivek Mandua / Madira Thresher was successfully designed and developed at VPKAS, Almora. This machine can thresh as well as pearl grains of finger millet, barnyard millet, proso millet and foxtail millet. Threshing and pearling of finger millet are done simultaneously, whereas in case of foxtail millet, barnyard millet, and proso millet, threshing and pearling are done separately. In order to mechanize the processing of small millets, the machine works well with more than 98% threshing efficiency and more than 90% pearling efficiency. The machine has threshing capacity of 60-80 kg and pearling capacity of 80-100 kg grains of finger millet in one hour. The machine has similar threshing capacity for barnyard millet with dehusking capacity of 2.5-4.0 kg grains per hour. These mechanized threshers were found ergonomically sound with respect to traditional method of threshing and are helpful in reducing physiological ergonomics parameters i.e. Heart Rate (HR), Energy Expenditure Rate (EER), Blood Pressure (BP), Pulse Pressure, Total Cardiac Cost of Work (TCCW), Physiological Cost of Work (PCW) and Blood Lactate Concentration and postural discomfort. On the basis of physiological ergonomic parameters and it was found that the per cent increase in heart rate by manual beating of finger millet was 8.78 which were reduced up-to 3.64 with thresher. The Total Cardiac Cost of Work (TCCW) and Physiological Cost of Work (PCW) were also reduced from 2017.5 to 1517.1 and 134.5 to 101.14 respectively, from millet thresher. Data for various other physiological parameters such as Percent changes in EER (Energy Expenditure Rate) from 31.43 to 14.39, Blood pressure 14.23 to 8.70 and Pulse Rate 40.86 to 16.78 were also recorded with millet thresher. Blood lactate concentrations (after activity) were also reduced with 14.7 to 7.94 mmol/l of blood with millet thresher These machines significantly reduce the work load and time spent for post harvest processing of small millets. This thresher has been well received by the cultivators as well as the development agencies.

Key words: *Drudgery; Post harvest technology; Ergonomics assessment; Finger millet threshing;*

Uttarakhand is located between 280 43' – 310 27' N latitudes and 770 34' – 810 02' E longitudes. The average annual rainfall of the state, as recorded is 1,547 mm. With an altitudinal variation ranging from 200m to more than 8,000m above mean sea level. About 70% of hills population is engaged in agriculture. More than three-fourths of Uttarakhand's total population depends on agriculture for their livelihood and the economy is predominantly dependent on mountain agriculture. However, the land holdings are small and fragmented, and irrigation facilities limited. The state faces the challenge of promoting livelihoods to retain people through local employment and income generation and to enhance their quality of life (*Surabhi Mittal et. al., 2008*). Agriculture is the major sector of the Hill State economy, in which the majority of people earn their livelihood. There is hardly any other major source of livelihood deriving from the secondary or tertiary sectors.

A global survey conducted by FAO shows that women account for 50 percent of overall food production in Asia. An FAO study on the role of rural women and food security in South Asian countries recognizes the

women's key role in post-harvest operations, seed management and maintenance of biodiversity. In addition, women are keen to transmit their complex knowledge to the youngsters in the family by involving them in the process (*Choudhury, 2000*).

Constraints and challenges in hill agriculture: Uttarakhand is largely rainfed, irrigation facilities are minimal, land holdings are small and fragmented, with a predominance of wastelands. Crop yields in Uttarakhand are low and there is a lack of effective marketing infrastructure including all post-harvest activities such as collection of the farm produce from the fields, transportation to warehouse, storage, processing, packaging, access to potential markets, information about prices, and finally marketing the produce at a price which is most remunerative to the farmer (*Chandra et. al., 2008*). In addition, there is a lack of availability and accessibility to horticultural inputs and the knowledge/information about suitable and remunerative crops and scientific management practices is scanty. Although, a lot of agricultural technologies have been generated for hills, yet it could not reach to the farmers and they are still practicing the subsistence farming. With the changing scenario of the state, need of farmers for cash income has become inescapable. Due to stiff competition, it is difficult to find jobs outside and therefore, agriculture is the only option they can depend on. Hence, it is very important that the improved agricultural knowledge be transferred to them for increasing their farm income.

METHODOLOGY

Finger Millet threshing was evaluated on the basis of physiological and psychological ergonomics parameters viz. Heart Rate, Blood Pressure, Energy Expenditure Rate, Total Cardiac Cost of Work, Physiological Cost of Work, Blood Pressure and Blood lactate concentrations for estimation of fatigue. A total of 50 farm women in the age group of 30-35 years with random sampling technique were taken for data collection. The activities were carried out with 3 replications and time bound for 30 min without rest break for analysis of various research parameters. Biomechanical stresses during performance of activities were measured by recording the incidence of body pain experienced by hill women in different body parts by administering body map Pains in different body parts due to faulty work practices were measured with the help of a suitable body map. In order to ascertain the degree of severity of pain, a five point scale for women was used.

Human Physical Drudgery Index (HPDI) of Finger Millet Threshing Activity: Human Physical Drudgery index can be calculated based on linear combination method using the scores obtained from Time spend on the activity, task performance score, difficulty score of the activity, body posture adopted, frequency of postural change, load/force and postural discomfort.

- *Step I- Time spent (hrs/year)* = time in hr/day x total no of days performed in a year
- *Step II- Task performance score*= Daily- 5, Alternate days-4, Weekly-3, Fortnightly-2 and seasonally- 1.
- *Step III- Difficulty score of activity*= Most difficult -5, difficult- 4, neutral- 3, easy- 2 and very
- *Step IV- Body posture adopted*= Upright-1, trunk flexion/extension $0\text{-}20^0$-2, trunk flexion $20\text{-}60^0$/ extension $>20^0$-3, trunk flexion $>60^0$-4 (Additional scores if back twisted +1, squatting/stooping +1, one or more body parts are static for longer than 1 min +1, repetition of activity +1)
- *Step V- Frequency of Postural change (no of times posture changes)*= 1-3 times- 1, 4-6 times- 2, 7-9 times-3 and >9 times
- *Step VI- Postural discomfort (pain/numbness/ tingling in body parts)*= Very severe-5, Severe- 4, Moderate-3, Light-2 and Very Light-1
- *Step VII- Load/force*= 0-5kg-score 1, 5-10kg-score 2, 10-15kg-score 3, 15-20kg score-4, >20kg-5

Formula for Calculating HPDI:

$$\text{HPDI} = \frac{Ai + Bi \ldots\ldots\ldots + Gi}{7} \times 100$$

HPDI = Human Physical Drudgery Index

RESULTS AND DISCUSSION

Gender specific drudgery in hill agriculture: Women development is key indicator of national development. Woman is the molder and builder of any nation's destiny (*IUCN, 2003*). They are regarded as the backbone of the rural scene (*Momin, 2009*). Women workforce outside the four walls is larger in rural areas than in urban India. FAO recognizes that food security and agricultural development cannot be achieved without

Fig 1. Processing of Finger Millet with traditional method

the full and equal participation of both women and men in rural areas (*Mahadik et. al., 2006*). Women play different but crucial roles in agriculture and rural development, and both contribute towards agricultural and food production. The crucial role of women in agriculture and allied activities has however been grossly under estimated and undervalued (*Parminder and Rabinderjeet, 2005*). It has been widely recognized that unless women's potential is properly developed, no transformation and economic development is possible. Therefore to accelerate the growth of any nation, it is very important to create opportunities for socio-economic development of women (*Singh et. al. 2008*). Drudgery reduction through technology interventions leads to improved productivity and health. Women make considerable contributions to agriculture in Hill India. Development of sustainable rural livelihoods cannot be pursued without understanding the scope of women's activities and problems. The drudgery of women's work in agricultural activities provides a justification for the introduction of labour-saving devices and technological innovation for productivity in agriculture. Various tasks performed by women not only demand considerable time and energy but also sources of drudgery for rural women (*Srinath K. et. al, 2010*). The result is that women's needs for comfortable work participation remain neglected. The problem of women relations to physical and mental fatigue, monetary hardship, exploitation, pain, economic stress, malnutrition, unemployment/underemployment are very often encountered in the society.

Post harvest processing of small millets: The production of small millet is higher in Uttarakhand hills therefore the post harvest processing of these millets need to be advent with mechanization so that the time consumption, excessive physiological demand of energy and fatigue level can be minimized with reference to drudgery reduction. Processing of small millets is one of the major activities associated with the farmer's drudgery. In hills, the processing of small millets is mainly done by women. The drudgery involved in manual processing of small millets is an important reason of reduction in consumption of small millets. The small seed size also makes processing of these crops difficult and time consuming. Development of disease resistant high yielding varieties with suitable production technology and good processing machines suited to small millet farmers are helpful in reducing the drudgery of farmers (*FAO and ICRISAT 1996*).

Role of VPKAS : Hill farmer play the most vital role in post production stage in agriculture operations. The millet threshing activity is full of drudgery and not supported by mechanical advantage in hill areas. Beating of millet bundle on wooden or stone platform is method farmers still practice in Uttarakhand although it has low output, higher grain damage and involved more drudgery to the farmers. V.P.K.A.S. is continuously involved in development of various farm mechanized technologies suitable for hills of N-W Himalayas. These technologies in-turn are able to reduce drudgery of hill farmers especially of women. Keeping in view the problems of threshing of millets, the institute has developed Vivek millet thresher cum pearler (Fig 2). This machine can thresh as well as pearl grains of finger millet, barnyard millet, proso millet and foxtail millet. Threshing and pearling of finger millet are done simultaneously, whereas in case of foxtail millet, barnyard millet, and proso millet, threshing and pearling are done separately. In order to

Fig. 2. Processing of Finger Millet with Millet Thresher

mechanize the processing of small millets, the machine works well with > 98% threshing efficiency and > 90% pearling efficiency. The machine has threshing capacity of 60-80 Kg and pearling capacity of 80-100 Kg grains of finger millet in one hour. The machine has similar threshing capacity for barnyard millet with dehusking capacity of 2.5-4.0 Kg grains per hour (*Anonymous, 2012*). Two models of these machines, electric thresher and engine operated thresher are available. These machines significantly reduce the work load and time for post harvest processing of small millets. This thresher has been well received by the cultivators as well as the development agencies.

Medical profile of women in hill region of North-West Himalayas : To make the evaluation of the agricultural women purposeful, the sample profile covering the demographic data of women, Physiological parameters (Table 1) in which medical history were considered. Data in Fig. 1 shows the medical profile of selected women agricultural workers during last one year. It was found that about 53 per cent of respondents suffered from fever which was reported temporary in nature Occurrence of headache, body ache, and irritation in eyes were also reported by commendable proportion (46.66, 60.00 and 13.33%) of respondents. Chronic illnesses as diabetes mellitus as well as occupation induced illnesses like tingling in hand were also reported by respondents in last one year.

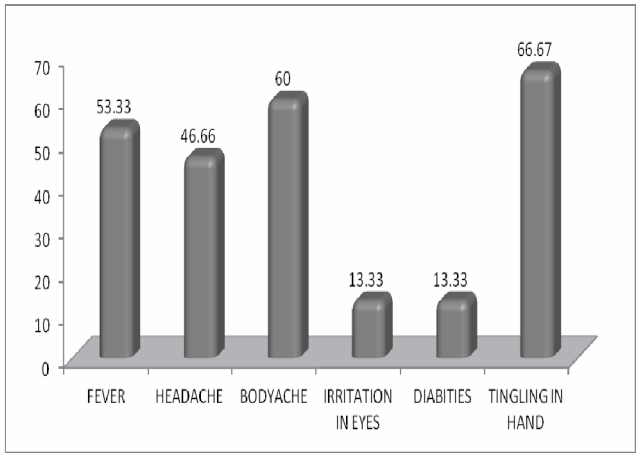

Fig. 3. Medical profile of women during last one year

Ergonomics evaluation of vivek millet thresher: Hill farmers play the most vital role in post production stage in agriculture operations. Manual threshing of millet is practice in Uttarakhand although it has low output, higher grain damage and involved more drudgery to the farmers.

Table 1. Physiological Characteristics of the Subject (N=50)

Physiological Characteristics	Mean	SD
Age, Years	23.5	2.31
Weight, Kg	48.5	3.19
Height, cm	152.5	3.1
HR rest, beats/min (3 replication)	75.73	2.19
HR max, beats/ min (3 replication)	116.10	3.54
Mean Blood Pressure (3 replication)	83.44	2.15
Pulse Rate (per min)	72.94	1.98
BMI, kg/m^2	20.98	3.51
Blood Lactate Accumulation	2.46	1.58

The mechanized thresher was found ergonomically sound with respect to traditional method of threshing and is helpful in reducing physiological ergonomics parameters i.e. Heart Rate (HR), Energy Expenditure Rate (EER), Blood Pressure (BP), Pulse Pressure, Total Cardiac Cost of Work (TCCW), Physiological Cost of Work (PCW) and Blood Lactate Concentration and postural discomfort.

Table 2. Ergonomic evaluation of Finger millet threshing activity (N=50)

Parameters	Finger millet (Madua) Threshing activity		't' value
	Traditional method	with millet thresher	
HR work, beats/min	127.8	97.5	2.60**
HR recovery, beats/min	82.5	74.56	3.67**
Percent increase in Heart Rate (Recovery Period)	8.78	3.64	2.05**
TCCW	2017.5	1517.1	2.84**
PCW	134.5	101.14	0.23
EER (KJ/min)work	11.60	6.78	3.57*
EER (KJ/min)recovery	4.39	3.1	2.52**
Percent increase in EER (Recovery Period)	31.43	14.39	0.57*
Mean BP work (mmHg)	98.52	78.64	2.51**
Pulse Rate work/min	96.58	78.20	1.85*
% increase BP	14.23	8.70	2.16**
% increase Pulse rate	40.86	16.78	0.06 NS
Blood lactate concentrat (mmol/l) work	7.94	2.94	3.54*

* Table value for significance at 0.05 level,
** Table value for significance at 0.01 level
NS- non significant

Madua (finger millet) threshing activity was evaluated on the basis of physiological ergonomic parameters and it was found that the percent increase in heart rate by manual beating of fingers was 8.78 which were reduced up-to 3.64 (Table 1) with Vivek millet thresher cum pearler. The Total Cardiac Cost of Work (TCCW) and Physiological Cost of Work (PCW) were also reduced from 2017.5 to 1517.1 and 134.5 to 101.14 respectively, from millet thresher. Data for various other physiological parameters such as Percent increases in EER (Energy Expenditure Rate) from 31.43-14.39, Blood pressure (14.23 to 8.70) and Pulse Rate 40.86 to 16.78 were also reduced with millet thresher. Blood lactate concentrations (after activity) were also reduced with 14.7-7.94 m mol/l of blood with millet thresher. Improvement and modifications in the existing tools, equipments, machinery and method of work has significant effect in minimizing in human strain and fatigue and increase farm productivity. Similar observations were also made by *Dewangan (2007)* and *Joshi P. et. al (2012)* while comparing the ergonomics of pedal threshers for paddy.

It was found from investigation that millet thresher was ergonomically feasible and helpful in reduction of cardio vascular stresses and blood lactate deposition (fatigue inducing agent) as compared to traditional method of millet threshing.

Human Physical Drudgery Index (HPDI) of finger millet threshing activity: Data pertaining to HPDI is depicted in Table 3. Human Physical Drudgery Index (HPDI) reduced with Millet thresher as compared to manual beating with significant reduction of drudgery with VL millet thresher.

Table 3. Human Physical Drudgery Index (HPDI) of Finger Millet Threshing Operation

Activity	Mode of Operation	HPDI
Finger millet Threshing	Manual Beating	84.9
	With Millet Thresher	48.7

CONCLUSION

Besides VPKAS, other Institutes also have developed a number of technologies helpful to reduce the drudgery in agriculture and allied sectors, which are available for dissemination. Mechanization is one important aspect which needs attention. Light weight, low cost machines suitable for use from sowing to harvest, storage etc would reduce the loss and drudgery of the farming community. The effective delivery mechanism of the research outputs is highly essential to harness the fruits of research investments. Transfer of technology by various means including print and electronic delivery would help in bridging the gap between the research farm and the farmers' field productivity. Providing suitable efficient technologies will also be helpful to create a renewed interest in this most important subject, which otherwise is highly challengeable as it faces a number of constraints including rainfed farming. This will also help in enhancement of economic status of hill farmers.

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