

EFFICIENCY AND ERGONOMIC EVALUATION OF FARM WOMEN FOR MAIZE SHELLING



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Regd.No. M/FRM/175/2017-18

Master of Science (Community Science)
in
Family Resource Management

COLLEGE OF COMMUNITY SCIENCE
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UNIVERSITY, BIHAR
PUSA (SAMASTIPUR) – 848 125

2019

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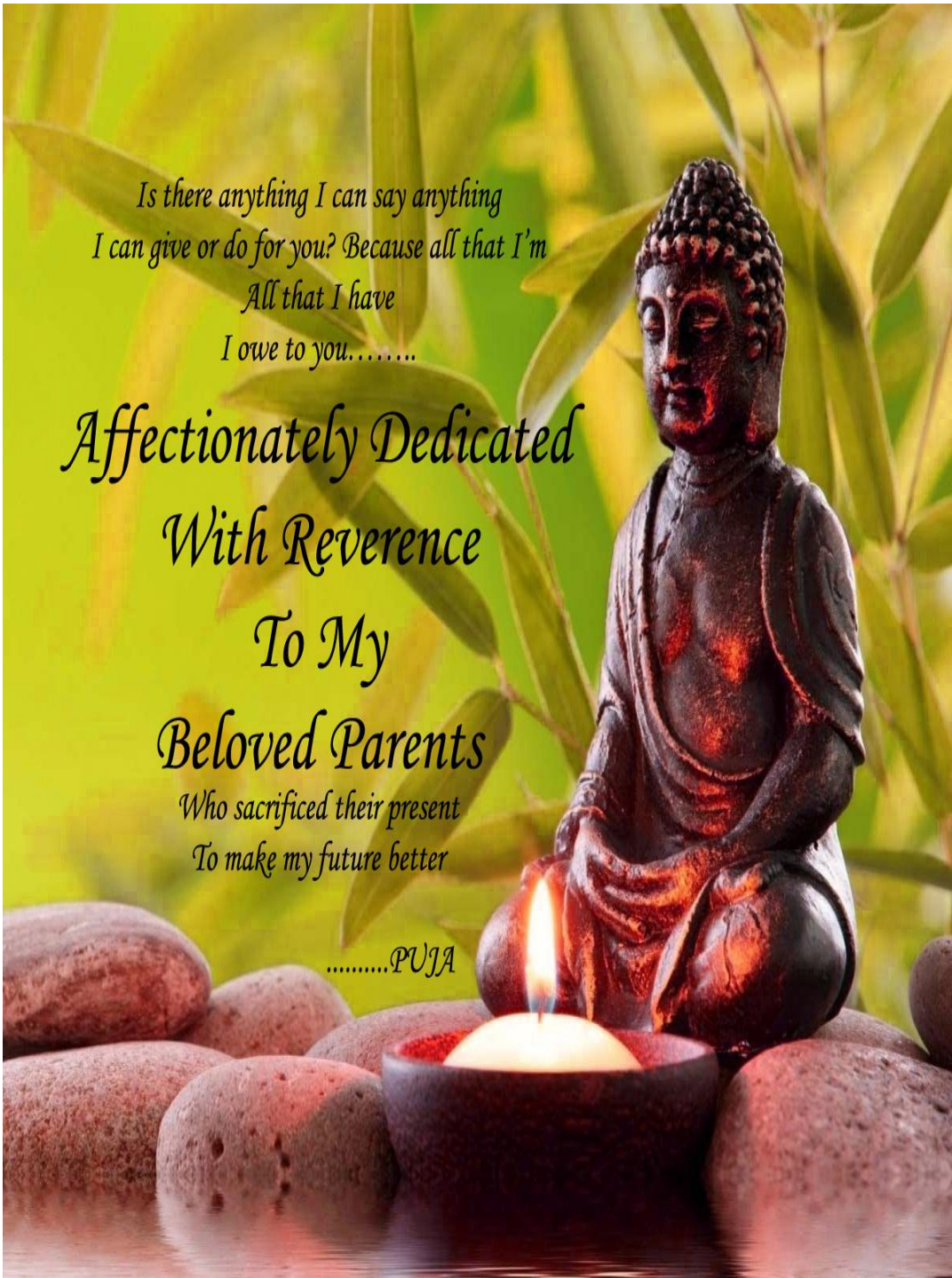
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Dr. RAJENDRA PRASAD CENTRAL AGRICULTURAL UNIVERSITY
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DEPARTMENT OF FAMILY RESOURCE MANAGEMENT

Dr. RAJENDRA PRASAD CENTRAL AGRICULTURAL
UNIVERSITY, BIHAR
PUSA (SAMASTIPUR) – 848 125

2019



*Is there anything I can say anything
I can give or do for you? Because all that I'm
All that I have
I owe to you.....*

*Affectionately Dedicated
With Reverence
To My
Beloved Parents*

*Who sacrificed their present
To make my future better*

.....PUJA

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Dated ...27/06/2019

Certificate-I

This is to Certify that the thesis entitled “**EFFICIENCY AND ERGONOMIC EVALUATION OF FARM WOMEN FOR MAIZE SHELLING**” in partial fulfilment of the requirements for award of the degree of **Master of Science in Community Science (Family Resource Management)** of the faculty of Post- Graduate studies, Dr. Rajendra Prasad Central Agricultural University Pusa (Samastipur) is a faithful record of bonafide research work carried out by **Miss Puja Kumari, Registration No. M/FRM/175/2017-2018** under my supervision and guidance. This result of the investigation reported in this thesis work have not so far been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation and source of literature have been duly acknowledged.

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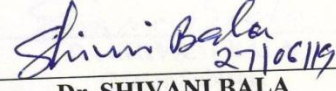
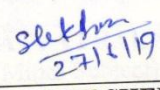
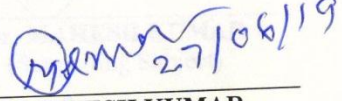
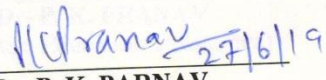
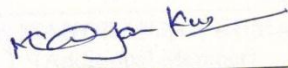
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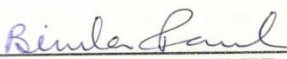

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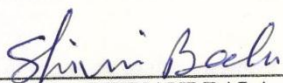
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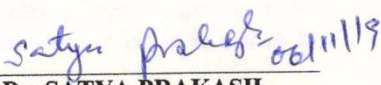
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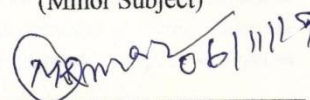

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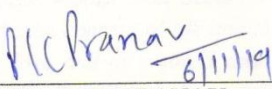

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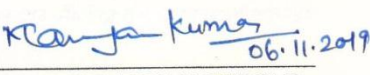
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With everlasting memories.....

Emotions cannot be adequately expressed by the words. My acknowledgements are much more than what I am expressing here.

The moment has come to look into the deeper layer of heart, which is filled with the feelings of togetherness, loveliness, consolation and satisfaction, a sign of relief and sense of fulfillment. Some are momentary and some are permanent, but both involve a number of near and dear persons to whom I acknowledge my warm regards and take this opportunity to express my feelings during the course of my research and it is putting down in black and white.

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Abstracts

Women produce more than 50 per cent of the total world food (FAO, 1995). Women's contribution in agricultural labour force in developed countries is 36.7 per cent while, it is about 43.6 per cent in developing countries. Women workforce in agriculture was 35.1 in 1991, which rose to 39 per cent in 2001 and it was agriculture and allied sectors is 98 million, which is 37 per cent of total wage workers (Census, 2011). They perform almost all agricultural activities right from sowing to harvesting and post-harvest activities. Most of the drudgery prone tasks for women in agriculture are cutting, uprooting, transplanting, weeding, sowing alongwith post-harvest tasks like manual threshing of maize, millet and pulses sieving and cleaning. Traditionally shelling of maize is done either by threshing cobs or removal of seeds by hand. Studies have revealed that the farm activities are time and labour intensive, monotonous, repetitive and more drudgery prone are generally performed by the women. Since all the operations are done manually, which cause considerable physical and mental fatigue and other health problems. The root cause of their sufferings is unawareness or ignorance about improved technologies, age-old methods of doing the work, inappropriateness of the technology and attitudinal constraints such as innate conservatism and resistance to change. Study was planned with objective to compare physiological work load and muscular pain and assess efficiency of Maize Sheller as compared to manual maize shelling.

The study was conducted in Samastipur District of Bihar state. Samastipur is one of the thirty-eight Districts of Bihar in India. The District also boasts of a Central Agricultural University in Pusa, well known as Dr. Rajendra Prasad Central Agricultural University Pusa, Samastipur, Bihar. From each selected village 30 respondents were selected by experimental was conducted on control group i.e 15 respondents from both the selected village and further information were gathered with the help of personal interview schedule.

The main purpose of this research is to evaluate the efficiency and ergonomic evaluation of farm women for maize shelling. Keeping in view the objectives of the

study, related information were gathered pertaining to socio- personal profile, anthropometric measurement of respondents, physiological problem during maize shelling activities, various crop parameters and machine parameter. For getting results of the study data were analysed by applying suitable formula and statistical method i.e. percentage, mean, standard deviation, coefficient of correlation and paired t-test were applied for getting accuracy of the results.

The result of the study indicated that the socio personal profile of farm women in control and general group was found different. The study reveals that in case of control group an equal number of respondents i.e 33.30 per cent were in each three category of age. Whereas in general group the maximum number of respondents (46.6 %) were in age group of 21-30 years. Under control group (63.3 %) respondents were having their large family size. Whereas in general group majority of women (53.3 %) were having large family size. So far as family education of control group is concerned a majority of respondents had medium family educational status (50%). In general group a majority of respondents were having their medium education level (43.3%). In case of control group a maximum of respondents (43.3%) were belonged to EBC category. But in case of general group maximum respondents (36.6%) were belonged to OBC category. In both control and general group majority of respondents (60 %) were involved in farming.

Data pertaining to ergonomic evaluation of farm women highlighted that in control group, majority of respondents had their body mass index (73.3 %) were in normal category. While in general group the majority of respondents (60%) were in normal category. Further the physiological data revealed that in traditional method the average energy expenditure of farm women was found higher (6.07 KJ m^{-1}) than the Univ. developed maize sheller i.e. 6.04 KJ m^{-1} respectively. In traditional method total cardiac costs of work and physiological costs of work of respondents were found to be (172.51) and (9.76) respectively. Whereas in University developed maize sheller total cardiac costs of work and physiological costs of work were calculated to (75.65) and (17.40) respectively.

The results pertaining to the output of machine which indicated that University developed maize sheller had its output of 70.20 (kg/hr) in comparison to traditional method 16.97 (kg/hr). This machine, findings highlighted that the output of the traditional method is very low. Average time taken for removing grain from five kg maize cobs was 17.68 minutes in case of traditional methods and by use of University developed maize sheller took only 4.28 minutes. The overall shelling efficiency of the traditional method was found to be 86.15 per cent, slightly less than the shelling efficiency of the University developed maize sheller was 87.73 per cent.

The correlation coefficient of twenty two selected independent variables correlated with three dependent variables. The analysis of results related to output revealed that in the age group of 21-30 years the independent variables such as family type (0.700*) was found to be significant at 5% level of probability. Whereas time (0.996**) came to be significant at 1% level of probability. In University developed Maize Sheller result shows that the independent variables such as family

size (0.693*) and height of respondents (0.650*) was found to be significant at 5 % level of probability. Whereas time (0.901**) came to be significant at 1 per cent level of probability. The analysis of results related to physiological cost of work revealed that in the age group of 21-30 years the independent variables such as family size (0.670*) and height (0.684*) was found to be significant at 5 per cent level of probability. While in the traditional method of maize shelling the posture inclination (-0.750*) was found to be negatively significant at 5% level of probability. While in the case of University developed maize sheller results shows that the independent variables like height (0.851**) was found to be significant at 1% level of probability. The analysis of results related to shelling efficiency of the machine revealed that in the under 21-30 years age group farm women the independent variables such as age (0.699*) was calculated to be significant at 5% level of probability. And posture Inclination (-0.699**) and moisture (-0.694*) was found to be negatively significant at 1% level of probability. While in University developed maize sheller results focused that the independent variable such as moisture (-0.667*) came to be significant at 5% level of probability.

Manual shelling of maize is a time consuming and tedious operation. The heart rate responses showed that the activity is light. Though the activity is light but the women feel it as a maximum drudgery prone activity because of its monotony in performance, continuous sitting and performing it for a longer period of time. Hence Univ. developed maize sheller was found to be the good manual tools for the women performing maizs shelling as it saves not only the time but also gives high output and efficiency of farm women was found twice and save cardiac cost of worker per unit of output in comparison to the hand maize shelling.



ABBREVIATIONS

<i>et al</i>	:	<i>et alia</i> (and others)
TM	:	Traditional Method
UDMS	:	University Developed Maize Sheller
BMI	:	Body Mass Index
DBP	:	Diastolic Blood Pressure
SBP	:	Systolic Blood Pressure
AHR _{res.}	:	Average Resting Heart Rate
AWHR	:	Average Working Heart Rate
AHR _{rec.}	:	Average Recovery Heart Rate
FES	:	Family Education Status
N	:	Number
gm	:	Gram
Kg	:	Kilogram
cm	:	Centimetre
hrs	:	Hours
MSV	:	Mean score value
SD	:	Standard deviation
Rs	:	Rupees
F	:	Frequency
%	:	Percentage
Fig	:	Figure
viz	:	Like

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CHAPTER - I



INTRODUCTION



INTRODUCTION

India is mainly an agricultural country, having farming as one of the largest occupations and India is a labour intensive industry, where rural women are the major labour force in agriculture. Women produce more than 50 per cent of the total world food (FAO, 1995). Women's contribution in agricultural labour force in developed countries is 36.7 per cent while it is about 43.6 per cent in developing countries. As per World Bank's 2014 report, the Indian female population comprised of 48.16 per cent of total population of our country. Women workforce in agriculture was 35.1 in 1991, which rose to 39 per cent in 2001 and it was agriculture and allied sectors is 98 million, which is 37 per cent of total wage workers (Census, 2011). They perform almost all agricultural activities right from sowing to harvesting and post-harvest activities. Most of the drudgery prone tasks performed by the women in agriculture are cutting, uprooting, transplanting, weeding, sowing alongwith post-harvest tasks like manual threshing of maize, millet and pulses sieving and cleaning. Traditionally shelling of maize are being done either by threshing cobs or removal of seeds by hand. Studies have revealed that the farm activities are time and labour intensive, monotonous, repetitive and more drudgery prone are generally performed by women. Since all the operations are done manually they cause considerable physical and mental fatigue and other health problems. The root cause of their sufferings is unawareness or ignorance about improved technologies, age-old methods of doing the work, inappropriateness of the technology and attitudinal constraints such as innate conservation and resistance to change. In rural areas about 60-70 per cent of agriculture operations is not work efficient and leads to cause drudgery. Ergonomics has a vital role in increasing the work efficiency with change in human behavior, abilities limitations and other characteristics to design of tools, machines, tasks, jobs and environments for productive, safe, comfortable and effective human use (Saunders and McCormick, 1992). It contributes for designing and evaluation of tasks, job, products, environments and systems in order to make them compatible with the needs, abilities and limitations of the people. Ergonomically designed items make the work more comfortable and workers more efficient.

Maize (*Zea mays* L.) is one of the most important cereal crop in the world agricultural economy. It is originated from **Mexico** several thousand years back, even before Columbus landed in South America. It is called as “**Queen of cereals**” and “**King of fodder**” due to its highly importance for human and animal food. It is a highly rich source of starch (60-80%), protein (8-12%), fat (3-5%) and minerals (1-2%) (Naveen Kumar, 2011 and Anon, 2013).

The maize grain has many food (grain, flour, syrup, oil) and non-food usages (cosmetics, adhesives, paints, varnishes). Maize starch and oil are also major products ([Ecocrop, 2010](#)). The maize grain is a major feed grain and a standard component of livestock diets where it is used as a source of energy. Other grains are typically compared to maize when their nutritional value is estimated. Many by-products of maize processing for flour (hominy feed, bran, germs, oil meal), starch (corn gluten feed, corn gluten meal) and alcohol/biofuel industries (distillers’ dried grains and solubles) can be fed to animals. Every part of maize has economic value as the grain, leaves, stalk, tassel and cob. All can be used to produce a large variety of food and non-food products. Maize has its significance as a source of a large number of industrial products besides its use as human food and animal feed. It is the major food and an important source of income for marginal and small farming community in many of the countries, particularly maize producing states like Bihar. Diversified uses of maize for alcoholic beverage, maize corn, starch industry, corn oil production, baby corns, popcorns etc. and potential for exports has added to the demand of maize all over world. Maize does possess tremendous potential in terms of feed for dairy, poultry and piggery agro-industries. Maize breeders have created many cultivars that correspond to specific climatic or agronomic conditions and uses. "Dent corn" maize is the most widely grown type of maize and the one typically used for feed. Other types (flint corn, popcorn, sweet corn, flour corn) are more intended for food uses. Some varieties have been developed to improve the industrial or nutritional value: high lysine, high tryptophan, high oil, high amylose, low phytate, etc. Brown midrib maize has a lower lignin content resulting in an increased digestibility in livestock. Genetically-modified (GM) maize varieties have been designed to improve grain performances (herbicide resistance, pest resistance, higher yields).

Since last one decade, under maize cultivation area is continuously increasing to meet the increased demand in the world. Maize ranks first in the world cereal

production which accounts 38 per cent of the total grain production with 868 million tonnes from 168 million hectare, whereas 30 per cent of wheat (691 million tonnes) and 20 per cent of rice (461 million tonnes) (Anon., 2011). United States has the lion's share of 43 per cent of the total world production followed by China (19%), EU-27 (6%) and Brazil (7%) account to 75 per cent of the total global production. India stands sixth in terms of production with 2.4 per cent to the total world maize production from 8.5 million hectare with 5 per cent share in the world harvested area (Anon, 2013).

Maize is the third most important cereal crop in India which accounts for 9 per cent of total food grain production in the country. Maize mostly grown in all the states and it is one of the most important staplefood. Among the cereal crops, maize ranks third in production of 21.57 million tonnes and fifth in area of 8.5 million tonnes (Anon., 2012). The area has increased from 6.6 million hectare in 2000-2001 to 8.66 million hectare in 2011-2012 (Anon., 2013b). In India maize is grown in all the seasons, of which nearly 90 per cent during Kharif season, 7-8 per cent during Rabi season and 1-2 per cent during summer season. Andhra Pradesh and Karnataka are leading producers of maize in India. Karnataka is the second largest producing state contributing to 17 per cent of total production (Sachin Chaudhary, 2016).

Bihar is one of the largest maize growing state and the crop was grown primarily as a subsistence crop to meet food needs for a long time till recently. Now it is also grown for commercial purposes (mainly to meet the raw material requirements of the animal feed sector) in non-traditional areas like Karnataka and Andhra Pradesh. It is third largest maize producing state contributing around 10 per cent to national production. Around 0.65 million hectare is presently under maize cultivation, which is about 7 per cent of Gross Cropped Area (GCA) in the state and over 13 lakh farmers are engaged in maize cultivation. During the year 2005 to 2006, the state produced about 1.4 million MT, which is about 5 per cent of the total crop production. In India maize crop is grown in all the seasons i.e., *kharif* (Monsoon), *rabi* (winter) and summer but it is essentially a warm weather (*kharif*) crop as nearly 90 per cent of the production is from *kharif* season and is rain dependent. It is cultivated during winter (*rabi*) in Peninsular India and Bihar. About 7-8 per cent of the production is during *rabi* season and the rest is from spring season (summer maize) grown mainly in Northern India. It is usually grown as a pure crop but is also grown as inter-crop with

different crop combinations like sugarcane, cotton, legumes, vegetables etc. Higher yields have been recorded in the *rabi* and spring crops. The higher yields are primarily due to long crop duration, better water management and lower incidence of disease and pests. Maize can be utilized in many different forms by converting it into a variety of products, through grinding, alkali processing, boiling, cooking and fermenting, such as corn starch, corn flakes and cereals, ethanol etc. It has many industrial applications, which can make it a profitable crop in the state. In Bihar only 8-10 per cent of maize (5 per cent directly by the processors and another 3-5 per cent is being used by road side snack joints etc.) is processed within the state despite the fact that the state has huge and rising marketable surplus.

Maize grain is harvested when it reaches its physiological maturity and contain 25-30 per cent moisture. Normally plucking the maize cob is dehusked-manually and then dried in sunshine to reduce moisture content to 15-21 per cent (db) for further shelling, where as in some part, harvested cob (undehusked) is dried in sunshine and then dehusking is done by hand prior to its shelling. Dehusking of cob is mainly performed by farm women in our state. The traditional practice followed by the farmers for taking out maize grain from cob (after dehusking) is either by beating the dehusked cobs with sticks or with finger or sickle etc. It is also observed that except beating with stick, removal of grain from rest method (finger sickle) is done by farm women. This operation is mostly performed by the traditional method and it is mostly done by the women at their household. At such times, maize shelling becomes a time bound activity. Though the maize shelling seems light but women feel it as a maximum drudgery prone activity because of its monotony in performance, continuous sitting and performing it for a longer period of time.

Manual maize shelling is a time-consuming, slow and tedious operation. The traditional system for shelling maize is to press the thumb on the grains in order to detach them from the cobs. This activity results in a lot of physical discomfort for the workers, resulting in damaged fingers with cuts and bruises. Continuous sitting in a definite posture has also its woes. Most importantly shelling maize by hands also consumes a lot of time. Moreover, the movements of thumb and fingers are repetitive and arms remain static, which worsen the situation. A constant repetition of movements imposes a cumulative work load which can cause pain and also weakness and impaired function of the muscles and other soft tissues (Gangopadhyay *et al.*,

2007). Azogu (2009) and D-Lab (2013) reported that approximately 550 million small-holder farmers in the world lack access to mechanized agricultural technology like industrial maize shellers due to the cost (ranging from US\$1,200-1,800) thus leaving rural dwellers with the option of shelling of high quantity of maize manually by hand or use of sticks. Various studies on women in agriculture pointed out the fact that women are generally employed in the operations which are either not mechanized or least mechanized, poor body postures may lead to increase in physiological workload and musculo- skeletal problems and involve a lot of drudgery. Thus, this operation is highly labour intensive with full of drudgery in addition to huge losses in quality and quantity of the agriculture produce. Drudgery is a term used to represent the dissatisfactory experiences on the part of worker that constraints work performance in any activity (Technical module/AICRPFRM/DRWA/2009).

Manes and Singh (2004) reported that 144.2 man-h/ha was required for harvesting and shelling of maize, which was next to the requirement in weeding of the crop. The energy consumption in shelling of maize cob was 16.49 per cent of total operational energy used in rainfed cultivation of maize crop in India (De, 2005). The labour requirement for dehusking and shelling is 12-13 man-h/tonne cobs and 65.8 man-h/tonne cobs, respectively (Vatsa *et al.*2007). This indicated the need of machines for dehusking-shelling of the maize cobs.

Now a day, Indian agriculture is getting modernized very rapidly. More and more hand tools, implements and machines are being developed, manufactured and used for performing various agricultural operations. A safe comfortable working environment for the operator becomes an important consideration, if productivity and customer satisfaction are to be enhanced (Gerke and Hoag, 1981).

Octagonal/tubular maize sheller, hand maize sheller, power-operated maize sheller and commercial power-operated threshers are available in the market for shelling the maize cob. The tubular maize sheller and hand maize shellers preferred by marginal and small farmers in some parts but at domestic level only. Dehusking of cob also requires huge labour and to mechanize this operation, power operated maize dehusker-shellers are becoming popular. These power operated maize dehusker-shellers are operated by 3.73 kW electric motor, 7.46- 8.95 kW dieselengine, 9.7 kW power tiller and tractor. This power operated maize dehusker-sheller and shellersuits

to slightly high income group. Ordinarily popular maize shellers are not capable of handling the un-dehusked cobs. To provide options before small farmers in form of small farm machines, hand or pedal operated equipment is needed. The equipment should be such that if required it could be attached with 1 hp or 0.5 hp electric motor. Keeping this in view, initial work on pedal operated maize dehusker-sheller was taken in 1980 at Udaipur. In this maize dehusker-sheller, half of the cylinder length was having rasp bars and the other half with rubber strips in octagonal cylinder to act as dehusker-sheller. This machine was operated by two men workers. It also might require more energy during its operation due to use of rasp bar as dehusking element. This might be some of the reasons for not becoming popular in addition to human-machine relationship. There was no other human operated maize dehusker-sheller available in market or research organizations. The manual-operated maize dehusker-sheller is also the need of hill farmers due to their topography and of marginal and small farmers of plain region. Scope of manual-operated equipment can also be visualized for under-developed and developing countries, if suitable equipment is available.

With the introduction of improved farm implements and machines, ergonomics become essential for its successful application. It is important to maintain a safe, healthy and productive environment for the farm worker. Ergonomics plays an important role in design of agriculture machines in the light of anatomy, physical and psychology of farm labour. It aims to enhance the effectiveness, productivity and efficiency with which work is carried out and to maintain or enhance such human values such as health, safety and job satisfaction. Comfort, physical welfare and performance of agricultural workers are influenced by the farm implements in terms of relevant features of human body such as body dimensions and body movements. More and more hand tools and implements are being developed, manufactured and used for various farming operations. All of them are either operated or controlled by human workers. Hence to achieve better efficiency of performance with more human comfort, it is necessary to design the agricultural implements, Keeping into the consideration of operators capabilities and limitation. However, few manual maize Sheller have been developed by the few Institutes; viz CIAE, Bhopal and PAU, Ludhiana, Punjab in India. But which are not easily available in the market. On the other hand, farmers face the problems in manual maize shelling especially the

breakage of the corn. Due to which women farmers are still using traditional methods to remove grains from the maize cobs and particularly in their unnatural body posture which affects the efficiency of farm women. However, Central workshop, Dr. RPCAU, Pusa has designed a women friendly manual maize sheller and the concept of maize sheller was given by the Hon'ble Vice Chancellor, Dr Rajendra Prasad Central Agricultural University, Pusa. This machine need to be ergonomically evaluated for its wide popularization in the state. Besides, the nature and extent of participation of farm women in agriculture activities are also affected by a host of factors, which include regional variations in nature of work, socio-economic status of the farm families and also the variation in agro-climatic conditions. Moreover, there is dearth of information on maize shelling activity performed by the women in our state. So keeping into consideration of these rational in mind this study has been planned with the following **objectives**-

1. To study the socio-personal profile and physiological status of farm women performing maize shelling.
2. To assess the ergonomic analysis of maize shelling performed by the farm women.
3. To compare efficiency of the existing University developed maize sheller over traditional method of maize shelling.

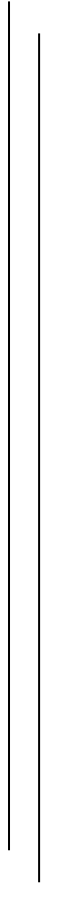




Plate :1 University Developed Maize Sheller



CHAPTER - II



REVIEW OF LITERATURE



REVIEW OF LITERATURE

A comprehensive review of studies is necessary in any research endeavor. A review of literature provides gainful insights, which could help in the development of instrument, selection of sample, interpretation of findings and discussion of the results of the research problem under study. Thus, this chapter is discussion of review of literature relevant to the present study. An attempt has been made to present here a review of the studies or the pertinent literature which is likely to have a direct or indirect bearing on the study. Keeping in view the objective of the study, the review has been presented under the following subheads.

- Socio-personal profile and physiological status of farm women performing maize Shelling.
- Ergonomic analysis of maize shelling performed by the farm women.
- Compare efficiency of the existing University developed maize sheller over traditional method of maize shelling.

Socio-personal profile and physiological status of farm women performing maize Shelling.

Gandhi S., (1996) studied on resource management of farm families and observed that the background information of the respondents (45.6%) were in the age group 25-35 years. Same trend was observed in different States except for Andhra Pradesh where majority of the respondents belonged to 35-50 years of age. Further education of the respondents indicated that more than half of the respondents (52.5%) were illiterate followed by primary (22.5%) where in U.P. education level of respondents was higher as maximum numbers of the respondents were up to matric (37.5%). Respondents with graduation (15.6%) and post-graduation (3.1) were also reported from this state only. Further, type of family indicated that 58.2 per cent of the respondents had nuclear family system as compared to the joint family system. While in Uttar Pradesh interstate variation revealed that the trend was reverse in Karnataka having more than half of the respondents (56.2%) belonging to the joint family system. While in Uttar Pradesh, it was equally distributed.

Eswaran *et al.*, (2000) focused that the women in agriculture make up a substantial portion of the rural population. Like men, they undertake various types of agricultural operations. Their involvement was found in seed treatment, sowing, managing, intercultural, harvest and post-harvest operations. Apart from participation in actual cultivation, women also participated in actual cultivation; processing and marketing of various agricultural produce.

Borah and Kalita (2002) revealed that, the average time devoted by women in agricultural operation is 8 to 9 hours per day in peak season and 4 to 5 hours in slack season. Except ploughing, cart driving and arranging inputs and marketing farm produce, women help in carrying out all other farm operations like compost making, sowing, weeding, application of fertilizer and manure, application of irrigation, protection from birds, harvesting, threshing, winnowing, drying, stacking and carrying were well documented.

According to Annual Report, CTR (2003) assessed the cultivation of tobacco consists of three major operations. They are nursery management, field operation, and post-harvest processing. Nursery management and post-harvest processing provide good employment opportunities to women. In plant protection operations, harvesting and stringing the ratio of women and men is 2: 1. The entire grading work of tobacco is carried out by women only. Raising nursery involves around 2860 women days per hectare, for a period of 90-100 days. The major contribution of women workers on tobacco nurseries weeding (46.6 per cent), closely followed by watering (21.2 per cent).

Bimla *et al.*, (2003) A study about women's participation in agricultural activities in Kaithal district of Haryana. It was observed that the investment of rural women in agricultural activities was to the extent of 73 per cent. A woman spends 74 minutes to 413 minutes per day in doing her agricultural activities. It was observed that the transplanting was the most drudgery prone activity (62.2 per cent) among all the agricultural tasks, crushing and intercultural ranked in second and third position.

Chairperson Advani (2005) observed that the pre or post-harvest technology in animal husbandry, poultry farming or fisheries not enough efforts have been made to reduce the drudgery of the women engaged in various farm operations. A profile of

women work force indicates that more than 80 per cent of respondents were engaged in the agriculture sector in rural India. It was indicated that 75 million women are involved in agricultural activities as compared to only one million men. However their contribution is largely unrecognized and mostly undervalued. Hardly any strategies have been planned to either improve their health or economic status (The Tribune, 2005).

Maiti et al., (2007) assessed the age related change and the gender differences of the pinch strength of adult male and female subjects and showed that men were significantly strong in pinch strength than the women in both hands. It was noted that the age had a significant effect on the pinch strength.

Singh et al., (2010) conducted a study on to minimize the drudgery of farm women in maize shelling in Chhindwara District. A tubular maize sheller was introduced and tested on farm women. To evaluate the shelling through ergonomic point of view, 20 respondents in the age group of 25 to 45 years were selected randomly and average age was counted as 34.5 years. The basic body dimensions were measured and respondents height and weight was found to be 151.4 cm and 48.60 kg respectively.

Ashish (2015) founded that a multidimensional study on women farmers in hilly area agriculture. Further the analysis of results showed that the majority of the women farmers (41.70%) belonged to relatively middle age group (36-58 years) followed by old aged (30.80 %) and (35 years and below) young age group (27.50%). This shows that newer generation is becoming alienated from agriculture. About 37 per cent of respondents had education at secondary school level, followed by 21.70 per cent had primary school education, 19.17 per cent were functionally literate, 13.33 per cent were graduate and only 10 per cent respondents were illiterate.

Ashish (2015) highlighted that a multidimensional study on women farmers in hill agriculture. The analysis of results showed that the majority of the respondents (65%) belonged to general caste category, followed by other backward classes (25%), schedule caste category (8.33%) and schedule tribe (1.67%). The population majorly constituted *Brahmins* as the land is called "*Dev Bhoomi*". A majority of the respondents (31.67%) were members of self help group, followed by co-operative

society (16.67%) and *panchayat* members (10%). About 28 per cent of the respondents were observed to be not member of any organisation.

Varma *et al.*, (2016) carried out study on “Effects of maize sheller on efficiency and ergonomic parameters of farm women”. Study was undertaken on 20 respondents in the age group of 25 to 45 years were selected randomly and average age was counted as 36.5 years. The basic body dimensions were measured and on an average women’s height and weight was calculated to 153.5 cm and 51.2 kg respectively.

Awasthi *et al.*, (2017) reported on “Efficiency Assessment of Maize Sheller in Context of Drudgery of Farm Women”. Further data analysed for knowing the socio-economic profile of the respondents. The finding that the majority of respondents were from the 25-35 years of age group (60.00%), illiterate (63.33%), schedule caste (60 %), farm labour (70 %), having monthly income up to Rs.10,000 from all the sources, belonging to nuclear family (78.89%) having 5-7 members in family(61.11%) and respondent had mesomorph body type (54.44). Physical parameters of selected respondents revealed that the mean height of respondents was noted to be 153 cm, mean weight 47.11 Kg and mean BMI 20.45 which highlighted that respondents were physically fit.

Ergonomic analysis of maize shelling performed by the farm women.

Sawkar *et al.*, (2001) conducted study on ergonomic assessment of occupational work load and rest allowances for female agricultural labourers in Dharwad. Rating of the perceived exertion (PRE) of the female labourers for the agricultural activities was heavy and very heavy in nature. The analysis of results indicated that as per mean and peak heart rate responses, it was evident that 39.5 per cent and 54.3 per cent of the female workers were working above the acceptable limits of workload. “Peak loads” of work seems to have an impact on the overall physiological stress. Hence, there was need for assessment of job-demand fitness compatibility. Based on the mean heart rate responses the rest allowance of 30 to 160 minutes was considered for the different agricultural activities.

Hasalkar et al., (2003) had reported study on ergonomic evaluation of drudgery reducing technologies for women in Agriculture through heart rate and perceived exertion. Sample size of thirty healthy women of 25-35 years, performing agricultural activities regularly, were selected for the study. Heart rate, energy expenditure and the perceived exertion of the farm women were taken as parameters, to evaluate the drudgery of selected farm activities experienced by the farm women with existing and improved tools and techniques. The results revealed that the physiological cost of work for farm women was reduced (by 0.84 beats/min) in weeding with improved weeding tools. The top dressing of fertilizer activity showed that heart rate of 2.07 beats/min reduction while working with the improved fertilizer trolley compared with existing method. The incidence of per cent musculoskeletal problem was reduced and the grip strength 4 kgs was improved with the use of improved tool/ techniques. The work output 10 per cent increased significantly while performing the selected farm activities with the improved tool/technique.

Mrunalini (2004) studied a ergonomic intervention in addressing the drudgery of women in water fetching activity. A proactive approach called “Participatory Ergonomic Intervention” was adopted to bring change in the work method by involving the user at all stages viz tracing the problem, technology design and evaluation and field trial. Three types of trolley designs was fabricated locally and 30 women were given access to use them. The feedback indicated satisfactory scores on securing postural comfort, productivity and stability of the trolley design. However, the users were found to give their hesitant responses for adoption. It was indicated that it needed efforts for social perusal and time span for bringing in a change from their habitual behavior. The participatory approach was demonstrated and a slight movement was found in the women’s attitude towards improving their quality of living, when they perceived their problems and contributed to the design of technology as an opportunity for improvement.

Zend et al., (2004) had conducted study on ergonomic evaluation of weeders designed to minimize the drudgery in selected farm activity-weeding. All the parameters selected for determining physiological workload indicated that physiological cost of work of weeding was increased by 13.33 per cent and 20 per cent when it was performed by using weeder I and weeder II respectively. The output

with weeder-I and weeder-II was 35.1 meter and 30.85 meter respectively as against 18.07 m² for traditional khurpi. It showed quite higher output with weeder-I and weeder-II was 94 per cent and 70 per cent respectively, as compared with the traditional Khurpi. As weeding is performed in standing position by using weeder-I and weeder-II it eliminates postural stress by reducing angle of deviation was noticeable. Field trials revealed that weeder-I functions very efficiently with higher coverage of land. Hence, weeder-I was recommended for efficient performance of weeding.

Badiger *et al.*, (2005) the commonly performed agricultural activities in India are weeding, cutting/ uprooting transplanting threshing and manuring. Drudgery is generally conceived as physical and mental strain, agony, monotony and hardship experienced by human beings. Three treatments namely weeding with traditional tool khurpi and with two improved weeders namely twin wheel hoe weeder and grubber weeder were observed with a sample size of 10 healthy women, without any cardio vascular complaints and performing weeding activity regularly. Heart rate was the major parameter used for analysis of the workload of farm women. The physiological cost of work was observed to be less with improved weeder twin wheel hoe (13.15 beats/min). Maximum increased work output was observed with grubber weeder i.e. 147 mtr followed by twin wheel hoe weeder. The weeder twin wheel hoe has proved to be very light while performing the weeding activity as perceived by the farm women.

Badiger *et al.*, (2006) carried out a study on the physiological cost of work done by the women for weeding. And it was observed that physiological cost of work was noted as lesser while worked with the improved weeder twin wheel hoe (13.15 beats/min) and also for grubber weeder (18.74 beats/min) compared to the traditional method of weeding. Hence both the improved weeders were proved to reduce the drudgery of farm women while performing the weeding in their field.

Borah and Oberoi (2007) carried out study on impact of drudgery reducing technology on farm women involved in the activity of cleaning animal shed. Study was undertaken on 30 farm women within the age group of 21-40 years to design and test some improved tools for performing the activity of cleaning animal sheds for reducing ergonomic cost. Ergonomic cost of work was assessed by heart rate, energy

expenditure, total cardiac cost of work (TCCW), physiological cost of work and rated perceived exertion (RPE). Heart rate was measured with heart rate monitor and other parameters were derived from the heart rate values. Rated perceived exertion was calculated on 5-point scale ranging from 1 to 5 point. Analysis of results highlighted that the improved tools for cleaning animal shed such as dung collector, long handled broom, spade and the double wheel barrow reduced the ergonomic cost of work to a significant extent in terms of heart rate, energy expenditure, TCCW, PCW and RPE.

Mohanty *et al.*, (2008) had conducted ergonomic assessment of farm women in manual paddy threshing. Study was taken up to have a comparative study on the ergonomic assessment of farm women in pedal threshing with single and double operators and to suggest modifications for further reduction of human drudgery. The mean heart rate work was found to be 135.9 ± 1.3 and 121.2 ± 1.0 beats/min respectively with single and double operators; a significant ($P < 0.01$) reduction of 10.82 per cent. The corresponding work pulse rate (Δ HR) was 65.7 ± 0.9 and 51.5 ± 1.6 beats/min. The Δ HR was more than the allowable limit of 40 beats/min. HR work steadied after 6 minutes of threshing and there was complete recovery of HR after 6 minutes with double operators and 8 minutes with single operator. The increase in HR/kg of grain threshed was found to be 146.4 ± 4.4 and 76.0 ± 4.1 in case of single and double operators respectively with a significant reduction of 48 per cent. The workload decreased by 13.5 per cent with double operators but was still higher than the allowable limit of 35 per cent of VO_2 max. The energy expenditure rate (ERR) was 18.9 ± 0.4 kJ/min with single operator and reduced to 16.6 ± 0.3 kJ/min with double operators. The total cardiac cost of work (TCCW) and physiological cost of work (PCW) reduced by 19.84 and 20 per cent with double operators. No significant variation of blood lactate accumulation between single and double operators was observed. The pedal force required was 232.3 ± 7.0 N and 199.7 ± 5.8 N in case of single operator and double operators respectively but was higher than the mean leg strength of the women of the eastern region of India. Higher pedal force application with double operators increased the number strokes/min (96/min) leading to a 51.15 per cent increase in output capacity of the thresher per hour per person. An increase of length of the pedal by 2 cm was suggested to reduce the force requirement. The length

of the threshing drum can be reduced from 60.5 cm to 40 cm to be used by single operator or it can be increased to 75 cm to comfortably accommodate two persons.

Naidoo *et al.*, (2008) carried out study on musculoskeletal pain in women working in small-scale agriculture in South Africa. The study revealed that the total 67 per cent (n = 574) of 12 month prevalence of pain ranged from 63.9 per cent to 73.3 per cent and the prevalence of specific chronic pain lasting more than 3 months ranged from 42.8 to 48.3 per cent. Older age, carrying heavy loads, working with hands above shoulder height and frequently squatting and kneeling were the reasons associated with chronic musculoskeletal pain.

Singh *et al.*, (2008) conducted a study on aerobic capacity of Indian farm women using sub-maximal exercise technique on tread mill. The study was carried out at NRCWA Bhopal sub-centre, CIAE, Bhopal on randomly selected fifteen farm women workers in two age groups of 25-35 year and 36-45 year, using sub maximal exercise technique on a computerized tread mill. Results showed the aerobic capacity of farm women, mean Vo₂max (aerobic capacity) for the age of 25 to 45 year was found to be 33.18 ml.kg⁻¹ min⁻¹. for the quick appraisal of the state of activity that may be continued for day long work with proper rest pauses, the heart rate levels of 120 beats per minute or work pulse of 40 beats per minute may be considered as optimal criteria. A linear relationship between heart rate and oxygen consumption rate was also observed and regression equations have been suggested for estimating the oxygen consumption rate of farm women, their measured heart rate data for agricultural activities in the field.

Gandhi *et al.*, (2009) reported on harvesting of bajra (pearl millet) cobs by farm women of Haryana – an ergonomic study. In that, the farmers do harvesting of bajra by cutting its ear heads first from standing crops. These cobs are then collected in a bag hanging on their shoulders and back that causes undue stress on the workers. This activity is performed by farm women which is one of the tedious activities where she adopts un natural body postures. Field experiment was conducted for 30 minutes on a sample of 30 farm women respondents. On an average, 24 kg of bajra cobs were cut observing average working, heart rate of 118 bpm over the resting heart rate (80bpm) consuming 10 kj/min of energy and assessing 58 bpm as physiological cost of work. There was 47.5 per cent increase in physiological stress on the women

making the bajra cobs cutting a moderately heavy activity. Hence, women reported maximum discomfort in their fingers, shoulder joints, upper back, mid back and upper arms. There is a need of intervention of appropriate technology Viz. improved sickle and pick bag to the farm women, which would be helpful to carry out the bajra cobs harvesting with lesser drudgery and increased output.

Swain *et al.*, (2009) reported physiological stress on women workers in pedal thresher. The study was undertaken in Orissa state. The field experiment was carried out with 50 female subjects in the age group of 18 to 45 years. Subjects were selected from OUAT central farm on basis of the anthropometrics data. Their heart rate, blood pressure, maximum aerobic power and oxygen consumption were measured in the laboratory at rest and work. Hence, the work pulse was found to be in the range of 54.2beats min⁻¹ for female agricultural workers. The mean value of energy expenditure rate was recorded to be 18.9kJmin⁻¹. The workers operated the thresher at 53.3 per cent of their maximum aerobic power. The mean arterial pressure and overall discomfort score was recorded to be 94.9 mm Hg and 6.8 respectively. The average pedal force applied was recorded to be 233.9 Newton. The body parts feeling discomfort were right legs, waist, hands, shoulder and neck. Maximum continuous working time for female agricultural workers was 34 minutes. Number of strokes per minute for female worker was noticed in the range of 95 to 104. The output of the thresher was observed to be 40 kg/hr.

Mrunalini *et al.*, (2010) found that women and men agreed to the factor viz. work load on time as principle contributing factor to drudgery at work. It was noted that gender showed low positive correlation with other factors contributing to their drudgery. The results highlighted that the therefore, guide that technologies which were that are selected for intervention for reducing drudgery shall be fundamentally time saving. Further, the researcher suggested that women must be relieving them from postural stress, feeling of exhaustion and difficulty. Technologies selected for men suggested to reduce manual load during work performance.

Singh (2010) had conducted study on ergonomical evaluation of cono-weeder with farm women. Interculture/weeding operation in paddy crop is very important operation which is done mostly in humid environment under scorch heat. Farm worker used to uproot the weeds by hand in bending position that might affect their

health. As known that weeds in upland rice field comes more easily than low land rice. A cono-weeder was ergonomically evaluated with 10 farm women at CIAE, Bhopal in upland rice field for transplanted rice by transplanter. Analysis of results highlighted that the mean heart rate of women workers during work was 153 beats/min and work pulse rate was 70 beats/min. higher heart rate may be due to non-performance of both cones of equipment which might need more force in the operation. The estimated oxygen consumption rate was 1.0642 l/min that is 64 per cent of their aerobic capacity (VO₂max). Higher average heart rate of worker in operation of this equipment suggests for use of equipment in small area with adequate rest pause to the worker. It is also suggested based on experiment that two workers may be engaged in shift for day long work with the equipment. The area covered was 165 m²/h. Average metabolic efficiency of worker was 9.18 per cent. If only one worker is engaged for the interculture/weeding operation with this equipment, 12–13 min rest could be provided. The equipment could be promoted after refinement for use by farm women.

Singh and Arora (2010) had studied an ergonomic intervention for preventing musculoskeletal disorders among farm women.. It was found that numerous types of musculoskeletal disorders such as disorders of the back and neck, nerve entrapment syndromes, tenosynovitis, tendonitis, peri tendonitis, epicondylitis and non-specific muscle and forearm tenderness were consequences of the occupational risk factors in agriculture including static positioning, forward bending, heavy lifting and carrying, kneeling and vibration. At the same time, ergonomic interventions were the potential to reduce musculoskeletal disorders among farm women. These may include designing of women friendly tools and equipment, improved work processes and stipulation of shorter rest periods for farm women. There is a need to increase awareness of musculoskeletal disorders and associated risk factors and to train farm women periodically for the proper and safe ways of handling tools and equipment in order to avoid musculoskeletal disorders.

Suthar et al., (2010) conducted a study on the impact of physical work exposure on musculoskeletal problems among tribal women. A random sample of 30 women was selected to draw the result of the study. Results indicated that work

related to musculoskeletal problem and disorders affect all the part of body viz. hands, shoulder, neck, back muscles in lower body region etc.

Borah *et al.*, (2011) observed that among the household activities, occasional activities such as pounding of rice, de-husking etc. required more time followed by child care and cooking. Time requirements for all landholding categories were almost same. Time spent in leisure time activities increased with increase in landholding possession except for large landholding. Further, the analysis of results showed that the most of the household activities performed by rural women are drudgery prone (using Drudgery Index). Introduction of household technologies as well as improvement of work methods would improve the health status of farmwomen to a great extent and enhance quality of life.

Sadhna *et al.*, (2013) studied on drudgery of farmwomen by introducing tubular maize Sheller for maize shelling. It was reported that maize sheller was found much better than their local practices in shelling efficiency (98% vs 91%), labour requirement (4 vs 6 man h /q), field capacity (25 vs 16.67 kg/ h) and damage/broken grains (1% vs 20%). It has also reduced the health hazards like hand pain, shoulder pain, backache and waist pain in majority of the respondents. Majority of the farmwomen (66.67%) perceived the tubular maize sheller as ‘most feasible’ technology’. Training on use of tubular maize sheller has resulted in significant gain in knowledge and skills of farm women.

Sharambir *et al.*, (2013) carried out a study and monitored that various drudgery related factors which were used for assessing the health of the farm women. For this purpose, 75 farm women were selected from five different villages of Ludhiana District. The introduced tools were maize sheller, improved sickle and ring cutter. The parameters for assessment of drudgery experience were drudgery scores, Ovako Work Assessment System, Cardiac Strain Index and Angle of Deviation. The results showed significant reduction in these parameters when improved tools were used as compared to traditional tools.

Singh (2013) assessed Hand operated maize dehusker-sheller, which was ergonomically evaluated with ten farm women to assess the physiological workload and its performance in standing and sitting postures. Two workers are required during

its operation, i.e., one for hand cranking and another for feeding the cob. One by one cob (without removing its outer layer/sheath) was fed in hopper at an interval of about 4 second. Farm women operated the equipment at their rhythmic speed in both postures. The average heart rate of subject was 144 and 142 beats per minute-1 in standing and sitting postures respectively. The overall discomfort rating (ODR) and Body Parts Discomfort Score (BPDS) clearly indicated that the standing posture could be better option for operation of this equipment. This was found to reduce the physiological cost by 38.95 per cent and 21.62 per cent in dehusking and shelling the maize cob with hand and dehusking by hand and shelling by octagonal maize sheller respectively.

Solanki et al., (2014) studied on the effects of jowar harvesting on a cardiovascular system of farm women by using different sickles and reported that in jowar harvesting mean heart rate of women workers during the work was 117.06 bpm with local sickle against 119.8 bpm and 126.56 bpm for MPU sickle cum khurpi and Vaibhav sickle respectively. There was an increase of 20.94, 20.85 and 21.86 b/m² of area harvested with traditional, MPU and Vaibhav Sickles. Thus, it can be concluded that use of improved sickle i.e. MPU sickle cum khurpi can help to reduce physiological workload and can give more output.

Gurupadesh et al., (2017) reported that participation of farm women was higher in 94.47 per cent gain in drudgery like grain storage activities, manual harvesting, picking of vegetables and animal dung collection and its disposal. Awareness level of participants regarding drudgery reduction tools was very low before trainings. After trainings, female laborers had 78.2 per cent gain in their knowledge regarding drudgery reduction techniques.

Compare efficiency of the existing University developed maize sheller over traditional method of maize shelling.

Kumar and Parvathi (1998) studied the energy expenditure of woman labourers for corn shelling using tubular, modified tubular and hand operated corn shellers. The energy expenditure was compared with the traditional method of shelling. Three female subjects with similar anthropometric parameters were selected to operate the corn sheller. It was estimated that the average energy expenditure for

operating the different manual shellers was 5-6 kcal min⁻¹. The output of the hand operated corn sheller was 23 kg/h⁻¹, 92 per cent higher than the hand operated, modified tubular and tubular corn sheller saved energy expenditure by 80, 60 and 52 per cent, respectively, compared to the traditional method. The energy requirement to work these shellers without fatigue was 2200 kcal day⁻¹.

Victor *et al.*, (2006) conducted an evaluation of the performance of a tractor powered maize sheller and shelling with tractor wheels. The performance of the maize shellers and the traditional shelling techniques were evaluated in terms of shelling efficiency, grain output and grain damage. The test results revealed that shelling of maize with tractor wheels incurred the highest per centage of grain damage. A maximum grain output of about 80 kg per hectare was obtained with the tractor powered maize sheller compared to 30.90 kg per hectare by shelling with tractor wheels and 13.19 kg per hectare with the traditional shelling techniques. Shelling with tractor wheels had the lowest shelling efficiency of about 73.76 per cent when compared with the other shelling methods.

Abdullah *et al.*, (2007) highlighted that the BARI manual maize sheller which is essentially a tubular shelling unit and wooden plank was incorporated to increase ease of operation and to avoid sitting problems while in operation. The performance of the sheller was tested in different locations at moisture content (12-23 per cent). The average capacity and shelling efficiency were found to be 35 kg/hr and 99.2 per cent respectively. It was estimated that the use of BARI improved manual maize sheller saved approximately 4-5 fold time and cost over the hand shelling method.

Anonymous (2007) reported the development of rotary maize cob sheller at CIPHET, Ludhiana. The sheller could be operated with one person. In this, cob was inserted into the sheller by one hand and pushed slightly against the fins. With the other hand the sheller was rotated by hand. The capacity of sheller was 60-65 kg cob/h. Another machine with two shelling units and four shelling units was also developed where two and three persons were required, respectively. Correspondingly, the outputs of machine were 100-110 kg cob/h and 170-180 kg cob/h.

Nkakini *et al.*, (2007) reported that manually powered sheller can provide a continuous flow at a speed of 60 rpm. A shelling effectiveness of 67 per cent was

achieved, with a low kernel-breakage factor of 0.09 and a throughput of 6.82 kg h⁻¹. This sheller uses abrasion between a rotating shelling-disc and stationary concave compartments to achieve the stripping. This design was preferred, because of its rapid operation, low human energy expenditure, low breakage factor for the kernels as well as relatively little dust being emitted during shelling; hence leading to a relatively-healthier local atmosphere for the operator. It's wider use was therefore recommended.

Mudgal (2008) studied 3.73 kW electric motor operated maize dehusker-sheller. Solid lugs of length 50 mm was used on beater of cylinder (990 mm length) for dehusking-shelling the maize cob. The capacity of machine was 0.8 t/h. The dehusking and shelling efficiencies were 99 and 98 per cent respectively. Four persons were required to operate the machine. It was reported that the optimum moisture content for dehusking-shelling maize cobs was 17 to 19 per cent.

Hassan *et al.*, (2009) fabricated maize sheller from locally available materials and its cost was very low and affordable. This machine was constructed to shell maize and separate the grains from the cobs. Its threshing efficiency was noted 99.2 per cent and breakage losses were insignificant. The machine threshes 200 kg of maize in a hour.

Alka *et al.*, (2010) conducted a study on Chhindwara District to minimize the drudgery of farm women in maize shelling. A tubular maize sheller was introduced and tested on farm women. The results showed that the shelling efficiency of tubular maize sheller was 26kg/hr as compared to hand shelling by which they only could shell 13kg/hr. and about 43 per cent saving in cardiac cost of workers per unit of output in comparison to the maize hand shelling.

Nwakaire *et al.*, (2011) observed the design, construction and performance analysis of a maize thresher for rural dweller. The communication methods used were an interactive sessions with farmers especially the women and children, in other to determine their shelling problems. Comparison was made between the human performance index for shelling and the machine performance index. The human mechanical efficiency, through-put capacity and grain handing capacity are 45per cent, 26.67kg/hr and 21.1kg/hr at a biomaterial test weight of 20kg with actual shelled

weight of 15.8kg at a shelling time 45 minutes. For machine indices, through-put capacity and the grain handing capacity of the sheller are 86 per cent, 119.76kg/hr and 109.99kg/hr respectively.

Singh et al., (2011) reviewed the status of maize threshing in India. The output in terms of dehusking shelling maize cob was reported that 30 kg per hectare with 8.3 per cent grain damage in traditional system (dehusking by hand and shelling by beating wooden sticks). The power operated maize dehusker sheller may be suitable for strong group of farmers (medium and large farmers) while in the country, about 80.3 per cent of farmers of marginal and small group operates 36 per cent of the area. The hand operated maize dehusker cum sheller was suitable for farm women workers.

Mahatale et al., (2012) observed that four method of maize shelling namely shelling cob grain by hand, octagonal maize sheller, hand operated maize sheller and beating by stick method were carried for removing maize kernel from the cob. For ergonomical evaluation ten male agricultural subjects of 25-35 year age group were randomly selected for the study. The mean OCR, Δ OCR, HR and Δ HR for octagonal maize sheller was the lowest among all method of maize shelling and highest for beating by stick method. The energy expenditure rate was highest for beating by stick method (3.84 kcal/min) and lowest for octagonal maize sheller (1.52 kcal/min). Energy expenditure rate for shelling cob grain by hand and octagonal maize shelling operation could be scaled in “Very light” category of work load. Whereas the hand operated maize sheller and beating by stick method could be scaled as in “Light” category of work load.

Singh et al., (2012) highlighted the dehusking and shelling of the maize cob are done mostly by the farm women in the country. This operation is mostly performed by the traditional method. To provide options for small and hill farmers, a hand operated maize dehusker-sheller has been designed, developed, fabricated and evaluated. Farm women could easily operate the machine with right or left hand. The output capacity with the machine was about 60 kg/h at a feed rate of 80 kg un-dehusked cob per hour. The dehusking efficiency was 100 per cent, shelling efficiency 98.8 per cent and grain breakage 0.3 per cent at a peripheral cylinder speed of 5.6 m s⁻¹. Two farm women (one for hand cranking and another for feeding

the cob) were required during operation of the machine. Both the workers could be shifted during operation to increase the continuity in operation.

Ilori *et al.*, (2013) studied about developing a model for the performance of the hand powered maize sheller. The power transmission increases the speed of the blower for high cleaning efficiency. Preliminary studies were carried out to determine the ergonomic data of operator and moisture content and grain/chaff. The results showed that maize with 12 per cent dry basis moisture content and grain/chaff ratio of 3.04:1 show that weight has the most significant effect ($p < 0.05$). The mean of the shelling efficiency, cleaning efficiency, sieve loss and mechanical damage of grain in the machine were noted as 94.3 per cent, 96.4 per cent, 2.3 per cent and 5.23 per cent respectively and the coefficient of determination for the regression equations relating the ergonomic parameters to machine efficiency and parameters ranges from 0.29 to 0.86 with quadratic regression obtained. Equations were derived to relate the variables and an approximate solution was obtained from a particular example, which validates the theoretical prediction with known results.

Ajaib (2014) conducted a study to evaluate the performance of different methods of maize harvesting and threshing i.e. manual harvesting and threshing with conventional maize thresher (T1), manual harvesting and threshing with maize dehusker-cum thresher (T2) and harvesting, threshing and cleaning using self propelled maize combine harvester (T3) in district Hoshiarpur of Punjab. Threshing efficiency of conventional thresher, maize dehusker-cum-sheller and self propelled maize combine harvester was in the range of 97-99 per cent, 97-98 per cent and 95-97 per cent, respectively. The total grain losses were highest (2-4%) for harvesting of maize with combine harvester and least (0.5-1.5%) for conventional maize thresher. The net cost of harvesting per hectare was the highest (Rs. 9000/-) in T3 and lowest (Rs. 2650/-) in T1. The total income from the maize residue per hectare was the highest (Rs. 5250/-) in T1 as compared to T2 (Rs. 3750/-) and T3 but there was saving of 100-140 man-h/ha as labour requirement for de-husking of the crop in T2 and T3. The maize residue left in T3 can be incorporated into the soil with rotavator operation which helps in improvement of soil health.

Clement *et al.*, (2014) conducted a study to design, fabricate and evaluate the performance of a power (motorized) maize shelling machine incorporated with blower. The main component part of the machine include; hopper, shelling Concave (top), spiked shelling cylinder (drum), perforated concave (bottom), cob outlet, fan, discharge chute/collector, shaft and frame. The machine measures 830x 605 x 950 mm. The performance evaluation was carried out using the NIS standard. The shelling speed and moisture contents of the maize cobs were varied. Results showed that shelling efficiency, cleaning efficiency, grain recovery efficiency and output capacity were 87.08 per cent, 95.89 per cent, 95.48 per cent and 623.99 kg/hr respectively at the highest values at 13 per cent moisture content and at 886 rpm shelling speed. The machine is able to remove the tedious parts of operation involved in hand shelling and manually within a short period of time.

Kumar *et al.*, (2014) conducted a research on design, development and evaluation of hand operated Corn Sheller in College of Agricultural Engineering during the year 2012-2013. The traditional shelling methods are rubbing the Corn cobs against each rubbing on bricks or stone and by using iron cylinder consisting of wire mesh inside. These methods are time consuming involves drudgery. In view of this, the study was undertaken to design, development and evaluation of hand operated Corn Sheller. The Corn Sheller consisted of a cylinder and a concave. The cylinder made up of high carbon steel of size diameter 21 cm. The cylinder length 86 cm, having beaters which rotates along the cylinder and separates grains from the cobs. While the concave was fabricated using 5 mm size mild steel rods. The length of concave was 91 cm with slotted opening size of 30.3cm×2.5cm. It was observed by the author that for hand operated corn sheller at a moisture content of 12 per cent w.b. and at a feed rate of 130kg/h, the shelling efficiency, unshelled per centage and visible damage was found to be 99.56 per cent, 0.44 per cent and 1.07 per cent respectively .

Hussen *et al.*, (2015) reviewed the modification and testing of jimma adjustable hand maize sheller in Ethiopia. It is more of the responsibility of women in rural Ethiopia to shell maize for household consumption which they mostly do it using conventional finger–palm method for the removal of kernels by pressing it between thumb and hand palm which is laborious and painful. Motorized and simple

hand held devices have so far been developed with objective of improving labor productivity, reducing the drudgery work and minimizing finger sore. However, lower shelling capacity of existing hand held devices and costs of motorized shellers necessitated availing mini hand maize sheller adjustable to a varying cob diameter and having an overall dimension of 30cm×11.5cm×27cm was developed. The test crop maize had grain moisture content of 14.7 per cent wet basis (w.b). Maize shelling using the developed hand sheller resulted in causing no damage to maize kernels at all. The results revealed that the sheller has mean shelling capacity of 26.26 kg/hr. Shelling efficiency 99.67 per cent was obtained. The average value for visible grain damage was 0.21 per cent and 0.13 per cent for sheller and conventional methods respectively.

Tripathi *et al.*, (2016) conducted study on minimize the drudgery of farm women in maize shelling in Mandsaur district (MP.). The results show that the hexagonal tubular maize sheller saves almost half the time and increases working efficiency 79.24 per cent and reduces 87.94 per cent drudgery of farm women over traditional practice. The cleaning efficiency was also found to increase 6.6 per cent. Hence, Maize Sheller is the best option for the women as it saves not only the time but also increases the efficiency of farm women timely.

Sanjeev *et al.*, (2016) conducted a study on Effect of maize sheller on efficiency and ergonomic parameters for farm women in Hoshangabad district of Madhya Pradesh to evaluate the efficiency and reduced the drudgery of farm women in maize shelling by tubular maize sheller. The results indicated that the maize sheller shelled 28.4 kg/hr as compared to sickle 18.7 kg/hr with increase efficiency of 34 per cent for maize crop.

Chilur *et al.*, (2018) highlighted that the Hyderabad Karnataka farmers (small-medium) are lack of ergonomic technologies with maize dehusking and shelling, which fulfils the two major needs as crops and as livestock in farming. The portable medium size (600 kg/h capacity) electric motor (2.23 kW) operated Maize Dehusker cum Sheller (MDS) was designed to resolve the issue by considering engineering properties of maize. The developed trapezium shaped MDS machine having overall dimensions (length × (top and bottom) × height) of 1200 × (500 and 610) × 810 mm. The selected operational parameters viz, cylinder peripheral speed

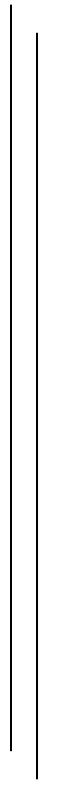
(7.1 m/s), concave clearance (25 mm) and feed rate (600 kg/h) were studied for machine-performance and seed-quality parameters. The performance of machine under these parameters showed the dehusking efficiency of 99.56 per cent, shelling efficiency of 98.01 per cent, cleaning efficiency of 99.11 per cent, total loss of 3.63 per cent machine capacity of 527.11 kg/kW-h and germination per centage of 98.93 per cent. Overall machine performance was found satisfactory for maize dehusking cum shelling operation as well as to produce the maize grains for seeding purpose.

Kumar *et al.*, (2018) highlighted the impact assessment of PAU Maize Dehuskar-Cum-Sheller with the Local Variety Devaki. Results obtained from this experiment shows that the threshing capacity was found 510 kg/hr with the rpm 740 and with 16 per cent moisture of maize cob. The dehusking capacity was also maximum at 16 per cent moisture content of cob was upto 85 per cent. No grain breakage was observed at the average cylinder speed of 740 rpm. A sharp decline in threshing and dehusking efficiency was observed at cob moisture content above 18 per cent. The cost of use of machine calculated with power source (power tiller) as prime mover has been found rupees 371 per hour or 68.70 per quintal whereas in case of traditional method it was found about 375 per quintal. There is a net saving of rupees 306 per quintal with respect to manual threshing.





CHAPTER - III



RESEARCH METHODOLOGY



RESEARCH METHODOLOGY

A systematic methodology is a base for a successful research. As it adds to clarity and precision of the finding related to the research problem. The present study on “Efficiency and ergonomic evaluation of farm women for maize shelling” was carried out by following step by step procedure. In order to fulfill the objectives, the methodology adopted for development of machine from ergonomically and mechanical considerations, ergonomical evaluation of Traditional method and developed machine to be operated by farm women. The details of the methodologies followed to carry out the present research have been discussed under the following sub heading:

1. Local of the Study
2. Sample and Sampling Procedure
 - Selection of District
 - Selection of the Block
 - Selection of the Villages
 - Selection of Respondents
3. Selection of Variables and Their Measurement
4. Tools and Techniques for Data Collection
5. Statistical Analysis of the Data

1. Local of the Study

The present study was conducted in Bihar State, which was selected was selected purposively as researcher is the resident of State.

Brief Description of Study Area:

Samastipur is one of the thirty-eight districts of Bihar in India. The district headquarters are located at Samastipur. The district occupies an area of 2904 km² and has a population of 27,16,929 (as of 2001 Census). The most important rivers traversing the district are Burhi Gandak, the Baya, Kosi, Kamla, Kareh and Jhamwari and Balan, which are both the offshoots of Burhi Gandak. The Ganges skirts the district on the south. Burhi Gandak enters the district from the west near Pusa and then pursues a south-easterly course till it leaves the district near Rosera.

Agriculture is the main economic occupation of the district and about 83 per cent of the total working population depends on it .It is the main stay of the people of the district while agriculture is utmost important for income generation. Some parts of the district is submerged with flood and water logging from July to November almost every year and drought occurs during kharif. Samastipur comes under the agroecological zone-I of the state i.e. North-West Alluvial plains. Agro climatic and farming situation of the district is given below.

Table 3.1 Samastipur District at a glance

S.No.	Particulars	Statistics
a.	General Information	
	Geographical Area (Sq. Km.)	2905
	Administrative Divisions No. of	4 381/1237 21
	Panchayats/Villages Number of	
	Tehsil/Block	
	Population (As per 2011 Census)	Total: 4261566 Rural: 4113769 Urban: 147797
	Average Annual Rainfall (mm)	1142
b.	Geomorphology	
	Major Physiographic Units	Gangetic Alluvium
	Major Drainages	Burhi Gandak, Kosi, Baya,Kamla, Kareh, Jhamwari and Balan
c.	Land use	
	Forest Area	Nil
	Net Area Sown	1749.24 sq.km
	Cultivable Area	2859.35 sq. km
	Principal crops	Potato, Tobacco, Maize, Rice and Wheat

(Source: RAU, Pusa, Samastipur, Bihar)

2. Sample and Sampling Procedure:

(i) Selection of District:

Samastipur District is at present comprises of 4 sub-divisions, and 20 Community Development Blocks. It has 5 towns, 3 Nagar Parishad, 381 panchayats and 1256 revenue villages. The District headquarters is located at Samastipur which is situated at the bank of Budhi Gandak river.

This District has a population of 3,413,413 (2001 census).The district is situated between 25°30'00'' to 26°05'00'' latitudes north & 85°37'50'' to 86°02'30'' longitude east. The total population of this District is 42,61,566, out of which rural population is 41,13,769 and urban population is 1,47,797 (as per 2011 census). The district boundaries, administrative divisions, major roads, rivers, and HNS locations are presented in Fig 1. Map of Bihar State.



Fig. 1.: Map of Bihar



Fig. 2: Map of Samastipur District of Bihar

(ii) Selection of Blocks

The two Blocks namely Pusa and Kalyanpur was selected purposively. One near by village was selected from each Block i.e Dhobgama and Malinager from Pusa and Kalyanpur Block respectively for convenience in data collection.

(iii) Selection of Respondent:

From each village 30 (thirty) respondents was selected. Thus, total number of sample size was comprised of 60 (sixty) respondents. All the 60 respondents involved in maize shelling activity were selected. Further out of 60 women respondents, 30 women respondents were taken as controlled group i.e 15 from both the selected village. The anthropometrical data (height and weight) of all the 60 farm women was taken. Experiment was conducted on control group respondents (30) in three replications with respect to maize shelling activities. In both methods, 5 kg of maize cobs were given to each respondent per replications. Time was observed with the stop watch.

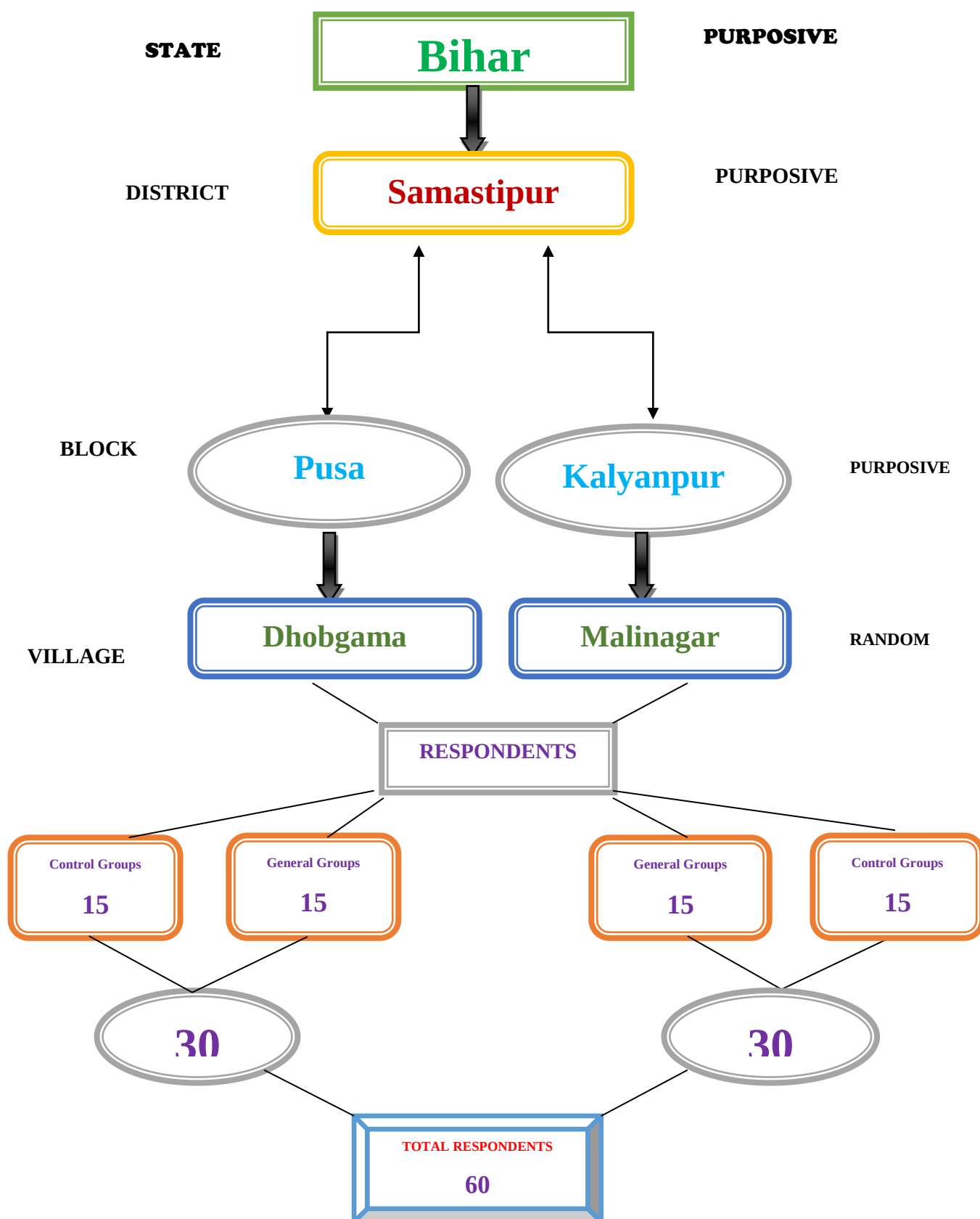


Fig.3 SAMPLING PROCEDURE

Selection of Variables and Their Measurement

The relevant variables were selected after getting the extensive review of literature, discussion with scientists and member of advisory committee. A brief list of these variables and their measurement tools / techniques are mentioned as below:

Table- 3.2 Variables and Their Measurements

I. Independent Variables		
S. No.	Variables	Measurement
1.	Human Parameters	
	A. Farm Women	
1.	Age	As per chronological age
2.	Family Type	Schedule developed
3.	Family Size	Schedule developed
4.	Family Education Status	Trivedi scale (1963)
5.	Caste	Schedule developed
6.	Occupation	Trivedi scale (1963)
7.	Income	Schedule developed
8.	Social Participation	Schedule developed
	B. Anthropometric Dimension	
1.	Height	Schedule developed
2.	Weight	Schedule developed
3.	BMI	Schedule developed
4.	Posture Inclination	Schedule developed
	C. Physiological Data	
1.	Heart Rate	Schedule developed
2.	Blood Pressure	Schedule developed
2.	Crop Parameter	
1.	Cob Dimension	Schedule developed
2.	Moisture Content of cob	Schedule developed
3.	Weight. of grain	Schedule developed
4.	Average number of Cobs per Kg	Schedule developed
	3. Machine Parameter	
1.	Time	Schedule developed
2.	Specification of Machine	Schedule developed
II.	Dependent Variables	
1.	Efficiency	Measured by the formula as, $\frac{\text{Work Output}}{\text{Work Input}} \times 100\%$
2.	Physiological cost of workers	Measured with the formula given by Varghese <i>et.al</i> , (1994)
3.	Output	Measured by the given formula as, Weight of maize cobs × duration /average time

(I) Independent Variables:**1. Age:**

It refers to the chronological age of the respondents and was measured in terms of number of years .Age of the respondents is a significant factor in inducing individual to get for different Blocks. In the present study the respondents are categorized in three groups such as 21 to 30 years, 31 to 40 years, 41 to 50 years.

Age	Score
21-30 Years	1
31-40 Years	2
41-50 Years	3

2. Type of Family:

Questions were designed to know whether the respondents were belonging to joint, nuclear or extended family. A score was given for variables assigned which is as follows:

Type of Family	Score
Nuclear	1
Joint	2

3. Size of Family:

Size of family refers to the total number of member in a family. Information on family size was categorized in to three different groups such as small, middle and large. Family size as a variable was assigned a score which is as follows:

Size of Family	Score
Small (Below 6)	1
Middle (6-10)	2
Large (10-15)	3
Very large (Above 15)	4

5. Family Education Status:

For the present investigation family education status (FES) was operationalized as the formal education obtained by the family members who were above six years of age. FES was measured with the help of following formula and on the basis of minimum maximum score obtained. It was categorized into three groups, which are as follows:

Family Education Status	Score
Low (2.1-3.8)	1
Medium (4.1- 5.8)	2
High (6.1- 7.8)	3

6. Caste:

Caste is a closed class system of a society which clearly distinguish the status and role for its members. The membership of which is determined by birth and is endogenous in nature (Trivedi Scale, 1963). In the present study the respondents are categorized in to five group such as General, Backward caste (BC), Extremely Backward caste EBC, Schedule caste (SC) and Schedule tribe caste (ST).

Caste	Score
General	1
OBC	2
EBC	3
SC	4
ST	5

7. Occupation:

The main source of earning livelihood was taken as respondents occupation. Numeral score was assigned to one's occupation as per the following scoring key.

Occupation	Score
No Work	1
Labour	2
Business	3
Farming	4
Government service	5
Other work	6

8. Family Income:

It refers to total amount of income earned by the respondents family in one month. In the present study the family respondent's income were divided in 4 groups. Family Respondents income as variables was assigned scores as follows:

Family Income	Score
Below 5,000	1
5,000-15000	2
10,000-15,000	3
Above 15,000	4

9. Social Participation

Operationally social participation has been defined as the degree to which the respondents were involved in formal organizations as a member of SHG or representative and regular in their attendance to meeting. The social participation was measured in research in research as under. The scoring is as below.

Social Participation	Score
No Participation	1
Member in past	2
Member in present	3
Member in past & present	4

10. Working Hours:

Standard working hours (normal working hours) refers to the legislation to limit the working hours per day, per week, per month or per year. The respondents working hours in this study means complete activities related to agricultural work, maize shelling activity. The scoring is as below.

Working Hours	Score
1-3 hours	1
4-6 hours	2
7-9 hours	3

The respondent's working hours in this study means complete activities related to maize shelling activity. The scoring is as below.

Working Hours	Score
0-2 hours	1
2-4 hours	2
4-6 hours	3
6-8 hours	4

Anthropometric Measurement of Respondents:

Anthropometry is the study of the measurement of the human body in terms of the dimensions of bone, muscle, and adipose (fat) tissue. Anthropometric measurement includes Height, Weight, BMI, Body Surface Area, Blood Pressure etc of a person.

(a) Height:

Height is the measurement of vertical distance, either how "tall" something is or how "high up" it is. For example- the height of a woman is 145 cm. In the present study, height was divided in 3 group. Height as variables was assigned scores as follows:

Height (cm)	Score
135-145	1
145-155	2
155-165	3

(b) Weight:

Weight is a quantity representing the force exerted on a particle or object by an acceleration field, particularly the gravitational field of the earth at the surface. For example weight of a woman is 52 kg. In the present study weight has been divided in 3 groups. Weight as variables was assigned scores as follows:

Weight (kg)	Score
40-50	1
50-60	2
60-70	3
70-80	4

(c) Body Mass Index (BMI):

Body mass index (BMI) is a measure of body fat based on the weight in relation to the height of a person and applies to most adult men and women aged 20 and over. For children aged 2 and over, BMI percentile is the best assessment of body fat.

$$\text{BMI} = \frac{\text{Weight in kg}}{(\text{height in meters})^2}$$

BMI	Weight Status
Below 18.5	Underweight
18.5 – 24.9	Normal
25.0 – 29.9	Overweight
30.0 and Above	Obese

In the present study weight were divided in 3 groups. Weight as variables was assigned scores as follows:

BMI	Score
Underweight (Below 18.5)	1
Normal (18.5-24.9)	2
Overweight (25.0-29.9)	3
Obese (30.0 and Above)	4

Respondents were categorized as per the body type:

Body type	BMI
Ectomorph	< 20
Mesomorph	20 – 25
Endomorph	> 25

(d) Postural Inclination:

The REBA (Rapid Entire Body Assessment) is also a postural analysis tool for the specified tasks with variations in the load, movement, distance and height. It is a quickly and easy observational tool for whole body activity (static and dynamic) giving a musculoskeletal risk action level. This assessment tool provides a scoring system for muscle activity in work posture. REBA involves assessment tool provides a scoring system for two segment A and B. Segment A includes the position of trunk, neck and legs and segment B includes the position of upper arm, lower arms and wrist. Table A and B provides for scoring of segment A and B and after ranking Table C (Annexure-II) is used for final score from 1 to 11 indicating to necessary action required now. The risk level score varies from 1 to 15 which indicated 1 is negligible risk level; 2-3 low; 4-7 as medium; 8-10 as high risk and 11-15 as very high risk level. (Appendix –II)

Ergonomic analysis of maize shelling performed by the farm women :

(a) Determination of physiological cost of work

Heart rate measurements technique was used to estimate the physiological cost of work. To know the heart rate of the subject digital heart rate monitor was used

- Average working heart rate (b.m^{-1}) (AWHR): Working heart rate was recorded with the help of Digital Heart Rate Monitor. It was taken till the completion of work both in traditional and improved method.
- Energy expenditure (Kj.m^{-1}): It was calculated by using the formula:

$$\text{EE (Kj.m-1)} = 0.159 \times \text{AWHR (bm}^{-1}) - 8.72$$
- Total cardiac cost of work (TCCW) (b.m^{-1}): Total cardiac cost of work was calculated by using the following formula:

$\text{TCCW} = \text{cardiac cost of work} + \text{cardiac cost of recovery}.$

Where,

Cardiac cost of work= (Average working heart rate - Average resting heart rate X duration)

Cardiac cost of recovery= (Average recovery heart rate - Average resting heart rate X duration)

Physiological cost of work (PCW) (beats): It was calculated by using the following formula

$$\text{Physiological cost of work (beats/min)} = \frac{\text{TCCW}}{\text{Total time of activity}} \times 100$$

Based on the heart rate (beats/min) and energy expenditure (KJ/min), classification of the Physiological workload was computed as per the classification of Varghese *et al.* (1996)

(b) Systolic Blood Pressure (SBP):

It is specifically the maximum arterial **pressure** during contraction of the left ventricle of the heart. The time at which ventricular contraction occurs is called **systole**. For example, with a blood **pressure** of 120/80 ("120 over 80"), the **systolic pressure** is 120. by "120" is meant 120 mm Hg (millimeters of mercury). **Systolic Blood Pressure** was recorded with the help of Blood pressure Machine. It was taken before start of work and after completion of work both in traditional and improved method of maize shelling activity.

(c) Diastolic Blood Pressure (DBP):

The **diastolic pressure** is specifically the minimum arterial **pressure** during relaxation and dilatation of the ventricles of the heart when the ventricles fill with **blood**. In a **blood pressure** reading, the **diastolic pressure** is typically the second number recorded. **Diastolic Blood Pressure** was recorded with the help of Blood pressure Machine. It was taken before start of work and after completion of work both in traditional and improved method of maize shelling activity.

(d) Postural changes:

Postural change was measured by simply counting the number of times the respondent changes the postures. At the end of work, the total number of postural

changes viz; standing, sitting and bending while performing the maize shelling activities done by the respondent were counted and documented.

(e) Grip Strength:

Grip Strength was measured with the help of Digital Grip Dynamometer. It consists of a handle for handgrip connected with a spring to a pointer on the marked dial. The grip fatigue was measured by asking the subject to pull the grip handle before the start of the activity with right and left hand respectively and readings on the dial in kilogram were recorded. Similar procedure was repeated immediately after the completion of the activity. Percentage decrease or increase in grip strength was calculated by the following formula.

$$\text{Grip Strength (\%)} = \frac{Sr - Sw}{Sr} \times 100$$

Where,

Sr= Strength of muscle at rest

Sw = Strength of the muscle at work

Assessment of musculoskeletal problems symptom frequency score to symptoms of maize shelling women

Incidence of musculoskeletal problems of the respondents were identified by using the body map viz. neck, trunk, legs, upper arm, lower arm, wrist, shoulders, fingers, upper back, lower back. The incidence of symptom frequency score and body tolerance to symptoms were recorded after the completion of the activity. The intensity of pain in the above stated parts of the body was recorded by using following scale having a five point scale (Ranjwan 2000).

Scale	Score
Very light	1
Light	2
Moderate	3
Severe	4
Very Severe	5

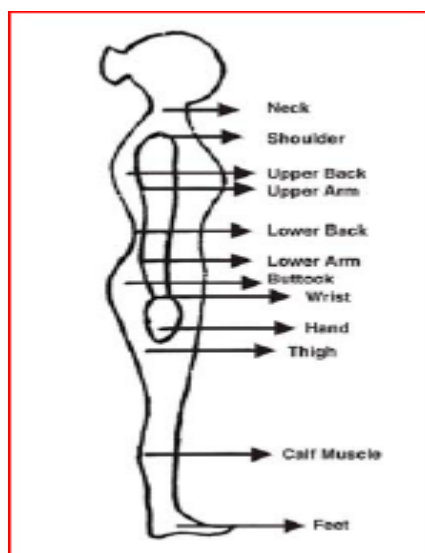


Fig No. 4 Body Map

Assessment of feeling of exhaustion, difficulty level problems faced by farm women

The following scale was used to know the feeling of exhaustion and difficulty level faced by farm women (ACRIP, FRM, Parbhani) while performing the maize shelling activity, which is as follows.

1. Rating to measure feeling of exhaustion

Scale	Score
Comfortable	1
Mildly Exhausted	2
Moderately Exhausted	3
Exhausted	4
Very Exhausted	5

2. Rating on difficulty level

Scale	Score
Very Easy	1
Easy	2
Moderately Difficult	3
Difficult	4
Very Difficult	5

Methods of Measuring Respondent's Opinion

The opinion scale used in the study was based on five point rating scale. The scale have been assigned score as 1,2,3,4 and 5 for strongly agree, agree, neutral, disagree and strongly disagree response choice for positive statements and these were in reverse order for negative statements. In order to arrive at the composite opinion score, the score obtained by each respondent for every statement were summed up. The final value thus computed was reckoned to be the opinion index of the individual respondent. On the basis of their opinion score the respondents were classified into three group namely low, medium and high as mentioned below.

The score thus obtained were calculated with applying the mean $\pm$ SD procedure to obtain low, medium and high categories of knowledge level of the respondents as given below

Group Score Obtained by an individual respondent for maize shelling performed with Traditional Method and University Developed Maize Sheller

Category	Score
Low	Low (Mean – SD)
Medium	Medium (Mean $\pm$ SD)
High	High (Mean + SD)

Field Acceptability of the University Developed Maize Sheller:

The acceptability of the University developed maize sheller was assessed by using the five point scale i.e. 1, 2, 3, 4 and 5 for strongly agree , agree, neutral, disagree and strongly disagree in case of positive statements and opposite for negative statements((*Annexure-I.C*). Scale was used on 15 statements covering the stress factors, tool design factors, field acceptability and the overall acceptability. The scale used was developed by the AICRP-FRM unit.

Procedure for calculating data: In order to arrive at the composite acceptability statement score, the score obtained by each respondent for every statement were summed up. The final value thus computed was reckoned to be the statement score of the individual respondent. On the basis of their statement score the respondents were classified into three group namely low, medium and high as mentioned below.

The score thus obtained were calculated with applying the mean $\pm$ SD procedure to obtain low, medium and high categories of statement score of the respondents as given below

Field Acceptability Score Obtained by an individual respondent for the University Developed Maize Sheller

Category	Score
Low	Low (Mean – SD)
Medium	Medium (Mean $\pm$ SD)
High	High (Mean + SD)

Crop Parameters for Calculating Maize Shelling Activity :

Apart from the machine parameters which affect shelling efficiency, crop properties also affect a maize sheller performance. These properties are:

(a) Variety of maize

Crop variety affects the shelling efficiency in that the differences in grain length, grain size distribution along the ear, kernel, and distance between grain rows might impair the use of a uniform clearance in a machine.

(b) Moisture content

It is important to measure the moisture content of maize grains as it will affect the efficiency of the machine. The content of grain should be reduced to 14% or less. It is therefore important to measure the moisture content before shelling in order to avoid damage to the grains. Moisture increases the deformability of a grain resulting in an increase in resistance to breakage. Hence, more energy is required to break a grain with adequate moisture content than the one with low moisture content. Moisture content of sample of cobs were measured by digital moisture meter at Farm Machinery Laboratory, College of Agricultural Engineering, Dr. Ragendra Prasad Central Agricultural University, Pusa.

(c) Shape and size:

Shape and size are closely related to physical factors of shelling efficiency in that they influence the shelling capacity of the manual maize sheller and grain loss through sieves..

Following crop parameters were calculated with the help of measuring tape. For calculation of these parameters randomly selected 10-10 sample from each cobs sample group.

- a. Length of cobs.
- b. Diameter of cobs.

(d) Weight of cobs

Firstly remove all foreign materials from cobs and then randomly select 10-10 sample of each cobs sample group and then weight them.

Machine Parameters :

(a) Unshelling of Maize grain (% by weight)

The percentage of unshelled grains from all the taken maize with respect to total grain as input measured by weighing machine. It calculated with the help of this formula given underneath.

$$\text{Unshelling grain (\% by weight)} = \frac{\text{Weight of Unshelling grain (kg)}}{\text{Weight of total grain fed (kg)}} \times 100$$

(b) Damaged grain (% by weight)

The percentage of weight of damaged grains in all maize cob outlets with respect to total grain. For the determination of percentage of damage grain, randomly take 4 samples. Weights of each sample were 250 gm and then separated the grain from sample and weight them. It was calculated with the help of this formula as mentioned below.

$$\text{Damaged grain (\% by weight)} = \frac{\text{Weight of broken grains (kg)}}{\text{Weight of total fed (kg)}} \times 100$$

(II) Dependent Variables:

(a) Shelling efficiency of Maize Sheller:

The shelling grain received from all the selected maize cobs with respect to total grain input. Shelling efficiency of both methods was determined with the help of this formula mentioned below

$$\text{Shelling efficiency (\% by weight)} = \frac{\text{Work output}}{\text{Work input}} \times 100$$

(b) Physiological cost of work:

Physiological cost of work is a an essential basis for evaluation and regulation of use of human beings as a source of mechanical power. Heart rate is an important parameters used as an indicator of physiological cost of work.

(c) Output (kg/hr):

Output capacity is defined as ability of the maize sheller to shell the weight of maize per hours. For the measurement of output capacity

$$\text{Output (kg/hr)} = \frac{\text{Weight of maize cobs}}{\text{Average time}} \times \text{Duration}$$

4. Tools and Techniques of Data Collection

(a) Collection of Data:

Personal interview method and experiment drawing efficiency of machine was used for the collection of data with the selected respondents. Respondents were explained about the aims and objective of the study before conducting the interview and were assured about the confidentiality of the information. Recording of measurement of various working dimensions, anthropometric and physiological data measurements of the respondents was done.

(b) Personal Interview of Respondents:

In-depth interview was carried out with selected respondents at their work place, to gather information about their personal characteristics, to know the kind of activities performed, posture adopted and problem faced while performing maize shelling activities in traditional method as well as newly developed University Maize sheller. The interview was carried out in a relaxed mood, so that farm women felt comfortable, while talking and giving information based in an interview schedule.

(c) Anthropometric and Physiological Measurement:

Different tools and equipment were used to take anthropometric data of selected respondents on pre-structured record-sheet. Relevant structural and functional anthropometric data were taken in different posture i.e standing, sitting, and squatting position of the farmwomen.

(d) Equipment and Techniques used for taking Information:

Suitable equipment and techniques were used for taking the anthropometric measurements i.e. Height, Width, Blood Pressure, grip strength, time etc. of the selected respondents. Equipment used for data collection is as follows:

- (a) Measuring Tape
- (b) Electronic Weighing Machine
- (c) Electronic Heart Rate Monitor
- (d) Blood pressure Machine
- (e) Grip Dynamometer

(a) Measuring Tape:

A narrow measuring tape marked in feet, inches and centimetre was used for taking the respondent's height. A metal scale was used for measuring the length and dimension of the selected maize cobs.

(b) Digital Weighing Machine:

A digital weighing machine was used to record the weight of the respondents in kilogram.

(c) Digital (Sphygmomanometer)/ Digital Blood Pressure Machine:

Digital blood pressure machine was used to measure blood pressure and heart rate of respondents during maize shelling activities performed.

(d) Grip Dynamometer :

It consists of a handle for handgrip connected with a spring to a pointer on the marked dial. It was used for calculating hand grip strength of the respondents.

(e) Stop watch :

Stop watch was used for measuring time during experiment. Time was displayed in minute and second. Further 1 second was divided into 100. Right side of the stop watch, there was a switch (button) which was used for starting and pausing the stop watch. Other button was on left side for setting zero. After each activity, the left button was used for setting zero.

(5) Statistical Analysis of Data :

The data collected from the respondents were put under scoring. Appropriate score were assigned to each of the responses of the respondents. Then these scores



Measuring Tape



Digital Sphygmomanometer/Blood pressure Machine



Digital Weighting Machine



Grip Dynamometer

Plate :2 Different Type of Tools Used For the Research



**Digital Weighing Machine for Measuring
Cobs & Grain**



Moisture Meter



Digital Vernar Caliper

**Plate :3 Different Type of Machine/Tool Used for Measurement of Crop
Parameters**

were put fourth for the statistical analysis of the study and results were drawn in term of frequencies, percentages and further mean, standard deviation, coefficient of correlation were applied for getting an accurate results.

Some important terms used in statistics population were conceptualized as follows:

Sample: Very often, as said earlier, for study of a large population, one resorts to sampling. It means the portion or group.

Frequency: The number of individuals or objects having the same measurement or enumeration count or lies in the same measurement group is defined as frequency.

Percentage: Percentage were used in descriptive analysis for making simple comparison. For calculating percentage, the frequency of a particular object or cell was multiplied by 100 and divided by total number of respondents in their particular category to which cell they belonged.

Variables: Any set of data contains information about some group of individuals. The information is organized in variables. Individuals are the objects described by a set of data. Individual may be people, but they may also people, but they may also be animal or things. A variable is any characteristic of an individual. A variable can take different values for different individuals. For each individual, the data contains the value of variables such as date of birth, gender, etc.

Data: Data are numbers with a context and we need to understand the context if we are to make sense of the numbers. Statistics is the science of learning from data. Data are numerical facts. Facts are a better basis for just making decisions than just guessing. To learn from data, we need more than just the numbers.

Score: The marks assigned to a student/ individual after assessing his/ her test paper in any test is called score. A score is a numerical summary of pupil's test or performance.

Random Sampling: Random sampling technique implies for selection of a subject like Unit, individual etc. included in the sample is determined by chance or not. A familiar example is dealing a hand of playing cards. The card a player receives is completely determined by chance.

Arithmetic Mean: Arithmetic mean was calculated by computing the sum of the column and dividing it by total number of respondents. The formula is given below:

$$\frac{\sum x_i}{n}$$

Where, x_i is the observation and n is the number of observation.

Correlation Coefficient: In order to study the association of variables under study, or to know the behaviour of two variables, correlation analysis was done. The formula to compute coefficient of correlation is as follow.

$$r = \frac{\sum XY - \frac{\sum X \sum Y}{n}}{\sqrt{\left(\sum X^2 - \frac{(\sum X)^2}{n}\right) \left(\sum Y^2 - \frac{(\sum Y)^2}{n}\right)}}$$

Where,

n = Number of Respondents

X = Independent Variables

r = Coefficient of Correlation between X and Y

T- Test:

T-Test is often called **Student's T-test** in the name of its founder "Student". T test is used to compare two different set of values. It is generally performed on a small set of data. T test is generally applied to normal distribution which has a small set of values. This test compares the mean of two samples. T test uses means and standard deviations of two samples to make a comparison. The formula for T test is given below:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

Where,

$\bar{x}_1$ = Mean of first set of values

$\bar{x}_2$ = Mean of second set of values

S_1 = Standard deviation of first set of values

S_2 = Standard deviation of second set of values

n_1 = Total number of values in first set

n_2 = Total number of values in second set.

The formula for standard deviation is given by:

$$S = \sqrt{\frac{\sum(X - \bar{X})^2}{n-1}}$$

Where,

x = Values given

$\bar{x}$ = Mean

n = Total number of values.





Maize shelling by Traditional Method

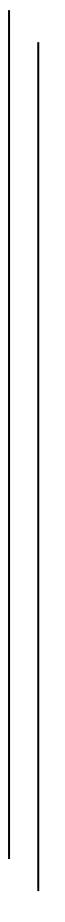


Maize shelling by University Developed Maize Sheller

**Plate :4 Different types of Maize Shelling Activities Performed
by the Farm Women**



CHAPTER - IV



RESULTS AND DISCUSSIONS



RESULTS AND DISCUSSION

In this chapter analysis of data and the results of the survey are presented and discussed to draw meaningful results, for “Efficiency and ergonomic evaluation of farm women for maize shelling”. Keeping in view the objectives of the study, the presentation of the results have been grouped under the following sections.

4.1 Socio- Personal Profiles of Farm Women Performing Maize Shelling.

4.1.1 Anthropometrical Dimension of Farm Women.

4.2 Ergonomic Evaluation of Farm Women Performing Maize Shelling.

4.2.1 Posture Inclination Analysis of Farm Women performing Maize Shelling.

4.2.2 Postural Change of Farm Women in Maize Shelling.

4.2.3 Grip Strength of Farm Women in Maize Shelling.

4.2.4 Musculoskeletal Disorders and Extent of Musculoskeletal Problem of Farm Women in Maize Shelling.

4.2.5 Assessment of Feeling of Exhaustion and Difficulty Perception while Performing the Maize Shelling Activity.

4.2.6 Opinion of Farm Women in Maize Shelling.

4.2.7 Time Management Practices of the Farm Women.

4.3 Comparative Evaluation of Efficiency of University Developed Maize Sheller and Traditional Method of Maize Shelling.

4.3.1 Physical Characteristic of Maize Cobs.

4.3.2 Efficiency of University Developed Maize Sheller over Traditional Method

4.3.3 Field acceptability of University Developed Maize Sheller

4.1 Socio-Personal Profile of Respondents

This section deals with the socio- economic profile of farm women. It is very much desirable to know the demographic and socio- personal profile of the respondents so that the finding of the study can be interpreted in the proper context to

draw a valid inference. The background information of the respondents with reference to their personal, demographic and family economic characteristics which are presented underneath.

Age :

The analysis of data presented in Table 4.1 revealed that on an average a majority of respondents (40 %) belong to age group of 21-30 years followed by the respondents (31.6 %) were in age group of 31-40 years and (28.3 %) were of 41-50 years. Under control group an equal number of respondent's i.e 33.30 per cent were in each three category of age. Whereas in general group maximum number of respondents (46.6 %) were in age group of 21-30 years followed by 30 per cent women who were in age group of 31-40 years and only 23.30 per cent respondents were 41-50 years aged.

Family Type :

The overall data indicated that a majority of respondents (68.3 %) were belonged to nuclear family and remaining 31.60 per cent respondents were having their joint family. Under control group majority of respondents (70 %) had their nuclear family followed by the respondents (30%) were having their joint family. In case of general group majority of respondents (66.7%) were from nuclear family followed by the respondents (33.3%) were having their joint family. Similar finding was reported by Awasthi *et al.* (2016) who also found that majority of respondents were belonging to nuclear family.

Family Size :

The analysis of overall data pertaining to the family size highlighted that a majority of respondents (58.3 %) had large family size followed by the respondents (28.3 %) were having their medium family size and only 13.3 per cent of respondents were their small family size. In case of control group (63.3 %) respondents were, having their large family size followed by the respondents had medium family size (26.7 %) and small family size (10 %). Whereas in general group majority of women (53.3 %) were having large family size followed by medium family size (30 %) and small family size (16.6 %) of the respondents. More or less similar finding was reported by Awasthi *et al.* (2016) who also found that majority of respondents having large family i.e (61.11%).

Education:

The overall data in Table 4.1 focused that maximum 33.3 per cent of respondents were illiterate followed by the (15%) farm women had education up to high school, intermediate (13.3 %) and graduation (11.6 %). In case of control group maximum of respondents were found to be illiterate (36.7 %) followed by the respondents had education above graduation (16.7 %), high school (13.3 %), Primary (10%) and Graduation (10 %). Whereas in general group maximum of respondents were illiterate (30%) followed by intermediate level passed respondents (20 %), high school (16.7 %), graduation (13.3 %) and only ten per cent can read and write.

Family Education Status:

The data pertaining to the family education status of women showed that a majority of respondents having medium family education status (46.6%) followed by low family education (31.6%) and high family education (21.6%). In case of control group majority of respondents had medium family education status (50 %) followed by low education level (30 %) and high education level (20%). So as far as general group respondents is concerned a majority of respondents were having their medium education level (43.3%) followed by the respondents had their low education level (33.3%) and high education level (23.3%).

Caste:

The overall data related to the caste indicated that a majority of respondents (36.6%) were belonged to EBC category followed by (33.3%) OBC category women, while only (18.3%) were SC and (11.6%) of ST category. In case of control group, it was reported that majority of respondents (43.3%) were belonged to EBC category followed by (30 %) OBC category, (16.7%) SC category and (10 %) ST category. But in case of general group maximum respondents (36.6%) were belonged to OBC category which was followed by the respondents (30 %) belonged to EBC, (20 %), SC and remaining (13.3%) respondents were belonged to ST category.

Occupation:

It was evident from the Table 4.1 that the (61.6%) of respondents in both general and control group were farming followed by (21.6%) were engaged in labour work. (10 %) respondents were not doing any work and only five per cent respondents having

engaged their own business. In case of control group majority of respondents (63.3%) were in farming followed by (23.3%) respondents were in labour group and (6.7%) respondents having their own business. While in general group (60 %) respondents were practicing farming followed by (20 %) were in labour and (16.6%) respondents were not doing other works, assigned by their parents.**Family Income (Monthly) :**

The data on family income in Table 4.1 showed that majority of respondents belonged to high income group (36.6%) followed by in the women were very Low income group (28.3%), low income group (23.3%) and medium income group (11 %). In control group maximum of respondents group (40 %) high income group followed by in very Low income group (30 %) low income group (16.7%) and medium income group (13.3%). While in general group (33.3%) were in high income group, (30 %) very low income group and (26.6%) low income group and (10 %) low income group respondents..

Social Participation:

Social Participation refers to the involvement of respondents as a member of any organization or institution. The overall data indicated that a majority of respondents is (66.6%) were member in the self-help group (SHG) at present time and remaining (26.6%) of the respondents had not participated in any organization. In control group, it was observed that maximum number of respondents that is (63.3%) were member in the self-help group at present time followed by 30 per cent respondents had their no involvements in any group. While in general group majority of respondents (70 %) were participating in the self-help group at present time and remaining (23.3%) of the respondents had not participated in any group.

Table 4.1 Social-Personal Profile of the Farm Women Performing Maize Shelling:**(n=60)**

S.No.	Parameters	Particulars	Control Group (F & P)	General Group (F & P)	Total (F & P)
1	Age	21-30 Years	10 (33.33)	14 (46.6)	24 (40.0)
		31-40 Years	10 (33.33)	9 (30.0)	19 (31.6)
		41-50 Years	10 (33.33)	7 (23.3)	17 (28.33)
2	Family Type	Nuclear	21 (70.0)	20 (66.7)	41 (68.3)
		Joint	9 (30.0)	10 (33.3)	19 (31.6)
3	Family Size	Small(1-3)	3 (10.0)	5 (16.6)	8 (13.3)
		Middle (1-5)	8 (26.7)	9 (30.0)	17 (28.3)
		Large (>5)	19 (63.3)	16 (53.3)	35 (58.3)
4	Education	Illiterate	11 (36.7)	9 (30.0)	20 (33.3)
		Can read write	1 (3.3)	3 (10.0)	4 (6.6)
		Primary	3 (10.0)	1 (3.3)	4 (6.6)
		Middle	1 (3.3)	2 (6.6)	3 (5.0)
		High school	4 (13.3)	5 (16.7)	9 (15.0)
		Intermediate	2 (6.6)	6 (20.0)	8 (13.3)
		Graduation	3 (10.0)	4 (13.3)	7 (11.6)
		Above	5 (16.7)	-	5 (08.3)
5	Family Education Status	Low (2.1-3.8)	9 (30.0)	10 (33.3)	19 (31.6)
		Medium (4.1-5.8)	15 (50.0)	13 (43.3)	28 (46.6)
		High (6.1-7.8)	6 (20.0)	7 (23.3)	13 (21.6)

Cont.....

S.No.	Parameters	Particulars	Control Group (F & P)	General Group (F & P)	Total (F & P)
6	Caste	OBC	9 (30.0)	11 (36.6)	20 (33.3)
		EBC	13 (43.3)	9 (30.0)	22 (36.6)
		SC	5 (16.7)	6 (20.0)	11 (18.3)
		ST	3 (10.0)	4 (13.3)	7 (11.6)
7	Occupation	No work	1 (3.3)	5 (16.6)	6 (10.0)
		Labour	7 (23.3)	6 (20.0)	13 (21.6)
		Business	2 (6.7)	1 (3.3)	3 (5.0)
		Farming	19 (63.3)	18 (60.0)	37 (61.6)
		Any other	1 (3.3)	-	1 (1.6)
8	Family Income (Monthly)	Up to Rs. 5,000	9 (30.0)	8 (26.6)	17 (28.3)
		Very low			
		Rs. 5,000-10,000	5 (16.7)	9 (30.0)	14 (23.3)
		Low			
		Rs. 10,000-15,000	4 (13.3)	3 (10.0)	7 (11.0)
		Medium			
		More than Rs. 15,000	12 (40.0)	10 (33.3)	22 (36.6)
9	Social Participation	High			
		No participation	9 (30.0)	7 (23.3)	16 (26.6)
		Member in present	19 (63.3)	21 (70.0)	40 (66.6)
		Member in past & present	2 (6.7)	2 (6.7)	4 (06.6)

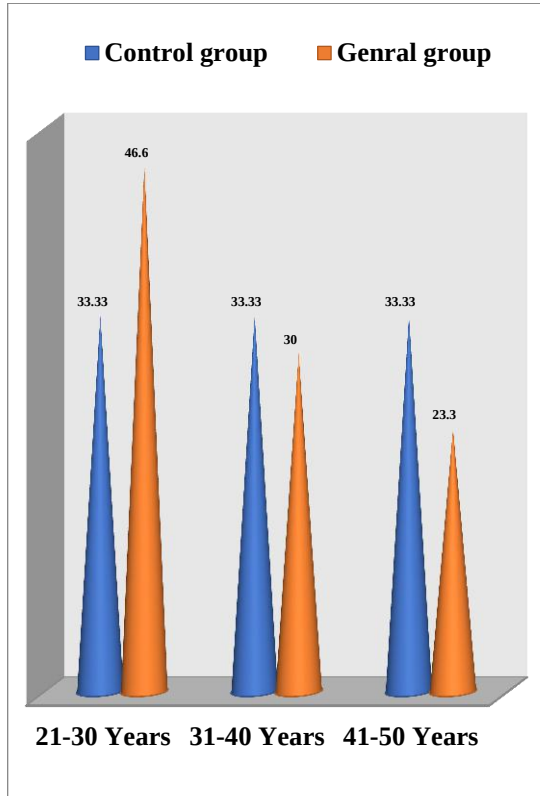


Fig. No. 5 Distribution of Respondents According to their Age

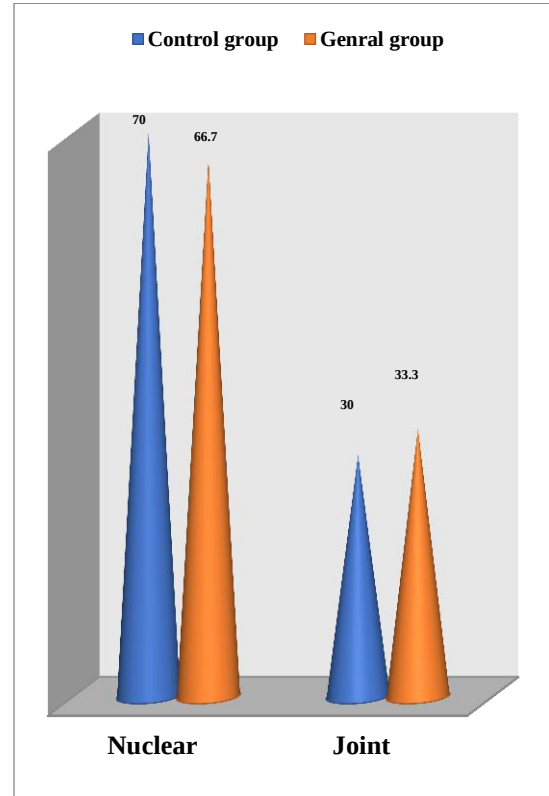


Fig. No. 6 Distribution of Respondents According to their Family Type

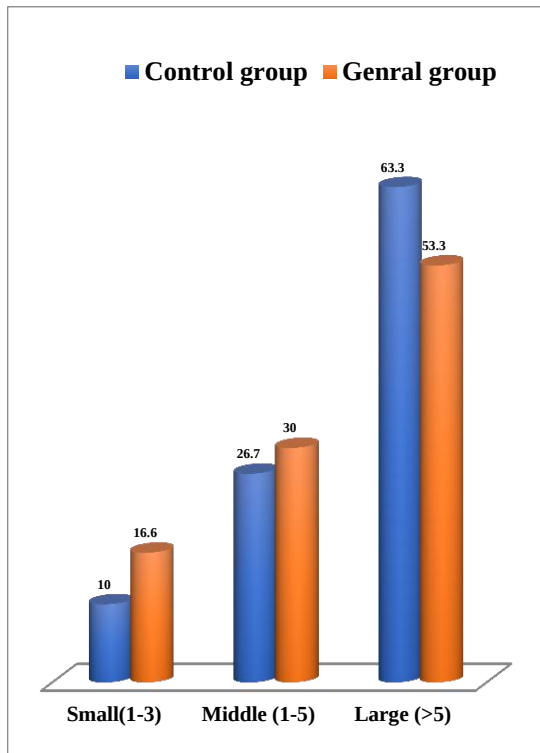


Fig. No. 7 Distribution of Respondents According to their Family Size

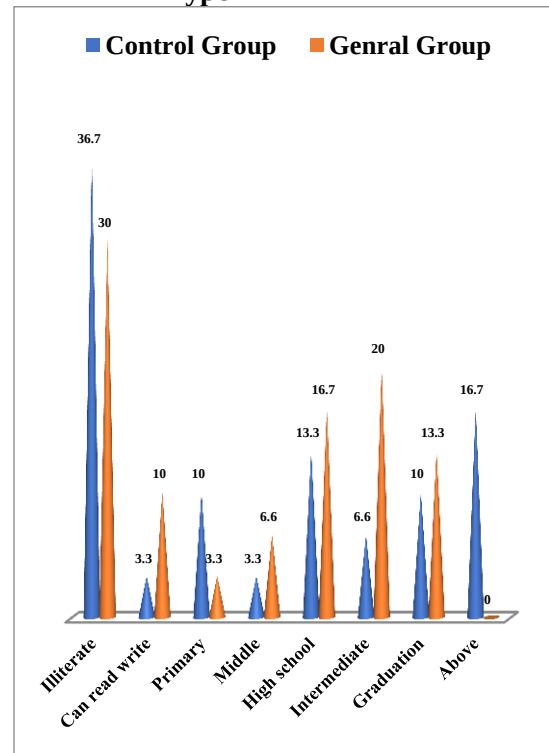


Fig. No. 8 Distribution of Respondents According to their Education

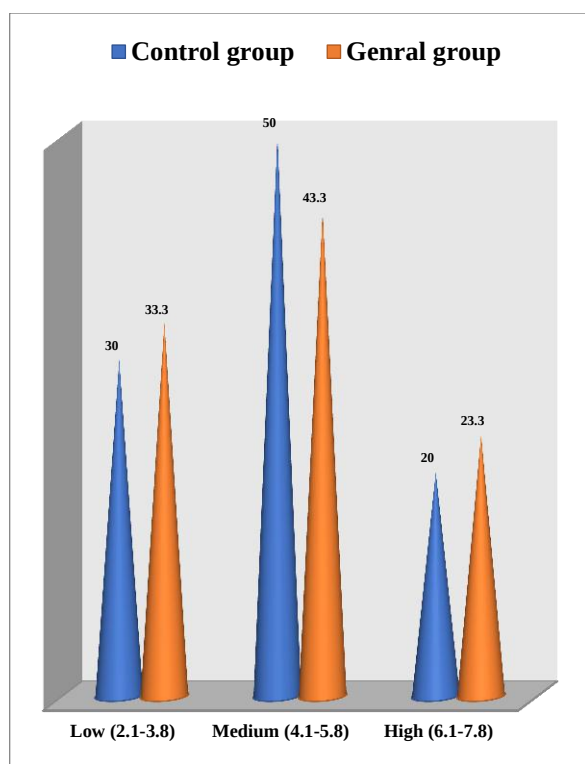


Fig. No. 9 Distribution of Respondents According to their Family Education Status

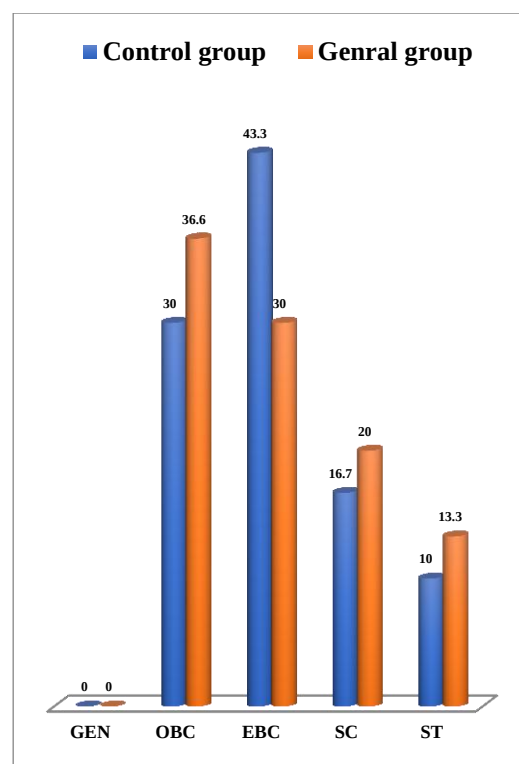


Fig. No. 10 Distribution of Respondents According to their Caste

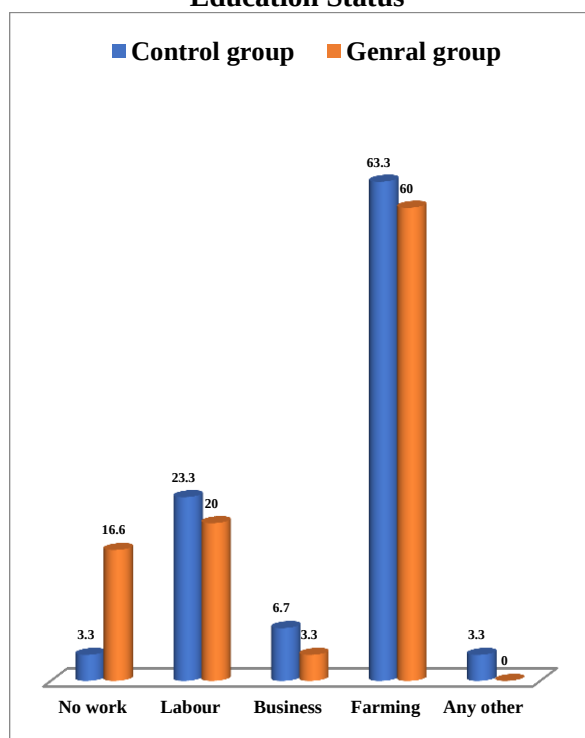


Fig. No.11 Distribution of Respondents According to their Occupation

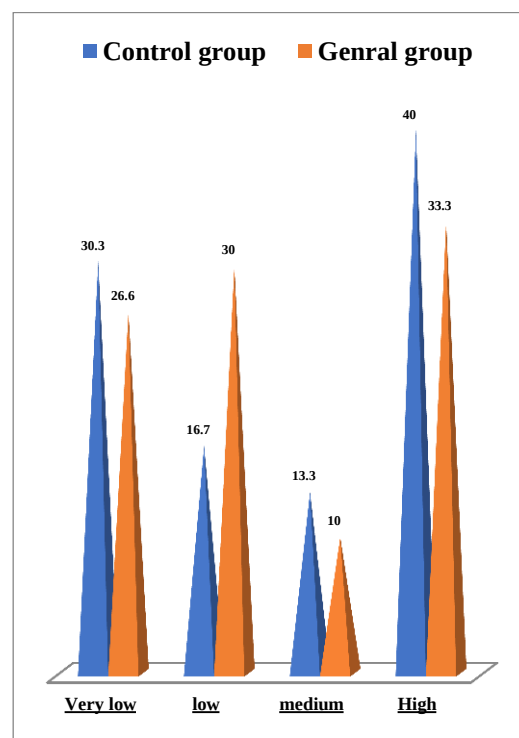


Fig. No. 12 Distribution of Respondents According to their Family Income

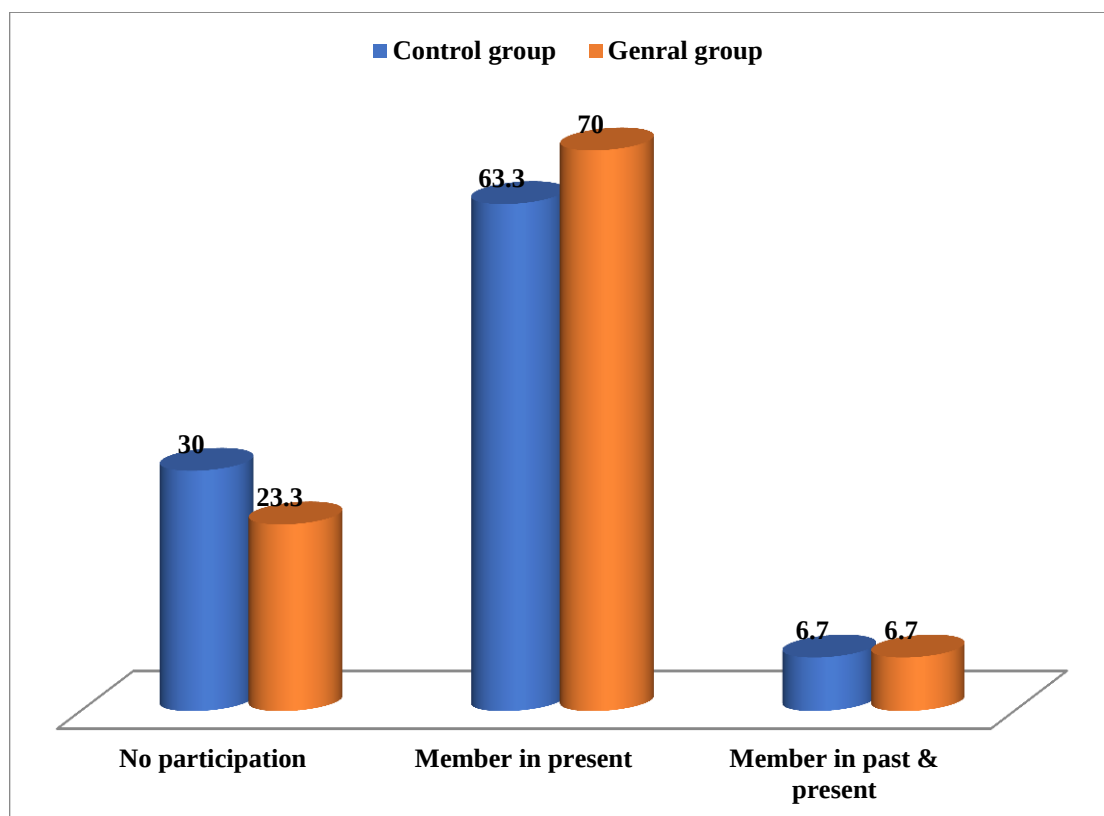


Fig. No. 13 Distribution of Respondents According to their Social Participation

4.1.1 Anthropometrical Dimension of farm women

Age, height and weight of the selected farm women were recorded and then body mass index of the farm women were determined to know the physical fitness and body type of the selected farm women.

Height:

The overall data given in Table - 4.2 that the majority of respondents (46.6 %) had their height ranging from the 155-165 cm and forty per cent farm women height were in the range of the 145-155 cm and only (13.3%) farm women height was ranging between 135-145cm. In the case of control group, the majority of respondents (43.3 %) had their height ranging from the 145-155 cm and thirty per cent farm women height were in the range of 155-165 cm and only (26.6%) farm women height was ranging between 135-145. In general group, the maximum number of respondents (60 %) had their height ranging from the 155-165 cm and forty per cent farm women height were range of the 145-155 cm. This finding is more or less similar with the findings Varma *et.al* (2016) who reported that on an average women's height was found to be 153.3 cm.

Weight:

The data showed that the maximum respondents (51.6 %) had their body weight under the range (40 to 50 kgs) followed by 33.3 per cent respondents had their weight was 50 to 60 kg and (13.3 %) respondents belong to the group of 60-70 kg. In control group maximum respondents (56.6 %) had body weight 40 to 50 kg followed by (30 %) respondents had their weight 50 to 60 kg and only ten per cent respondents falls in their weight group under (60-70 kgs). While in general group (46.6 %) respondents weight was 40 to 50 kg followed by (36.6 %) respondents weight was 50 to 60 kg and only 16.6 per cent respondents were having their body weight of 60-70 kg. This finding is supported by Singh *et.al* (2010) who has found that majority of respondents body weight was 48.60 kg.

Body Mass Index:

The data pertaining to Body mass index of the respondents shows that the majority of respondents (66.6 %) were in normal category (20.5-25) followed by (16.6 %) in the underweight category (18.5-20.5) and only (11.6 %) of them were in overweight category. In control group the majority of respondents (73.3 %) were in normal category (20.5-25) followed by (13.3 %) respondents falls in the underweight category (18.5-20.5) and only (10 %) of them were in overweight category. While in general group sixty per cent of respondents were in normal category (20.5-25) followed by twenty per cent in the underweight category (18.5-20.5) and only (13.3 %) of them were in overweight category. Similar finding was reported by Tripathi *et al.* (2016) who also found that the mean body mass index was calculated to be 22.56 which meant that respondents were in the normal category.

Body Somatotypes:

The overall data regarding body type of the selected farm women (Table 4.2) revealed that the majority of the farm women had mesomorph (48.3 %) body type followed by ectomorph (35 %) and few (16.6 %) were in endomorph category of body type. In case of control group sixty per cent of the farm women belonged to the mesomorph body type category followed by ectomorph (26 %) and few (13.3 %) were in endomorph category of body type. While in general group the majority of the farm women belonged to the ectomorph (43.3 %) body type category followed by mesomorph (36.6 %) and twenty per cent were in endomorph category of their body

type. Hence, it can be concluded that majority of selected farm women were in normal category followed by the respondents belonged to mesomorph category of body type.

Table 4.2 Anthropometrical Dimension of Farm Women

(n=60)				
S.No.	Particulars	Control Group (F & P)	General Group (F & P)	Total (F & P)
1.	Height (cm)			
	135-145	8 (26.6)	-	8 (13.3)
	145-155	13 (43.3)	11 (40.0)	24 (40.0)
	155-165	9 (30.0)	19 (60.0)	28 (46.6)
2.	Weight (kg)			
	40-50	17 (56.6)	14 (46.6)	31 (51.6)
	50-60	9 (30.0)	11 (36.6)	20 (33.3)
	60-70	3 (10.0)	5 (16.6)	8 (13.3)
	70-80	1 (3.3)	-	1 (1.6)
3.	Body Mass Index			
	Underweight (Below 18.5)	4 (13.3)	6 (20.0)	10 (16.6)
	Normal (18.5-24.9)	22 (73.3)	18 (60.0)	40 (66.6)
	Overweight (25.0-29.9)	3 (10.0)	4 (13.3)	7 (11.6)
	Obese (30.0 and Above)	1 (3.3)	2 (6.6)	3 (5.0)
4.	Body Somatotypes			
	Ectomorph (< 20)	8 (26.6)	13 (43.3)	21 (35.0)
	Mesomorph(20- 25)	18 (60.0)	11 (36.6)	29 (48.3)
	Endomorph (>25)	4 (13.3)	6 (20)	10 (16.6)

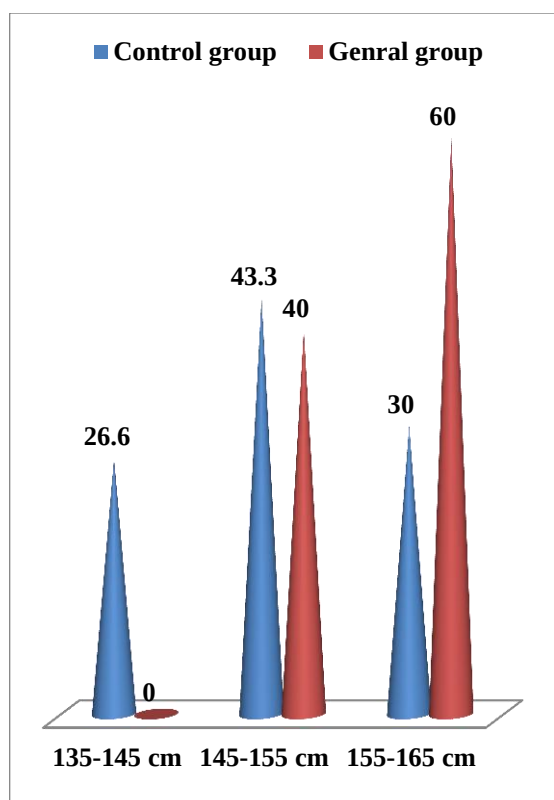


Fig. No. 14 Distribution of Respondents According to their Height

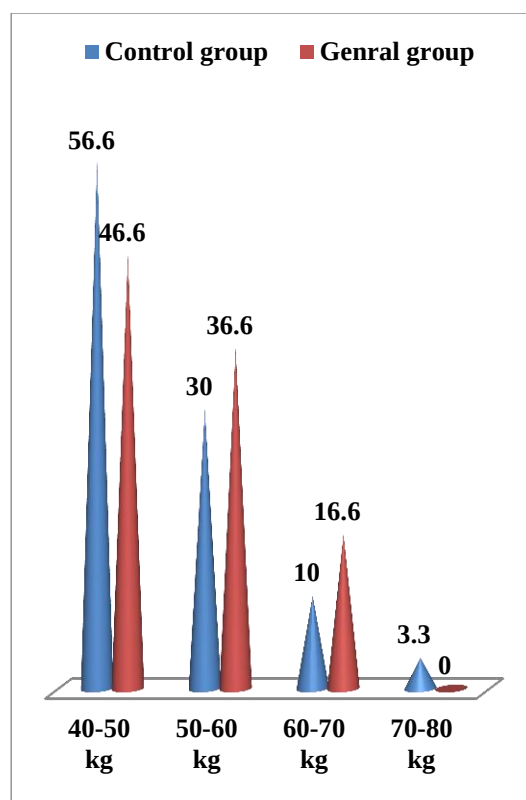


Fig. No. 15 Distribution of Respondents According to their Weight

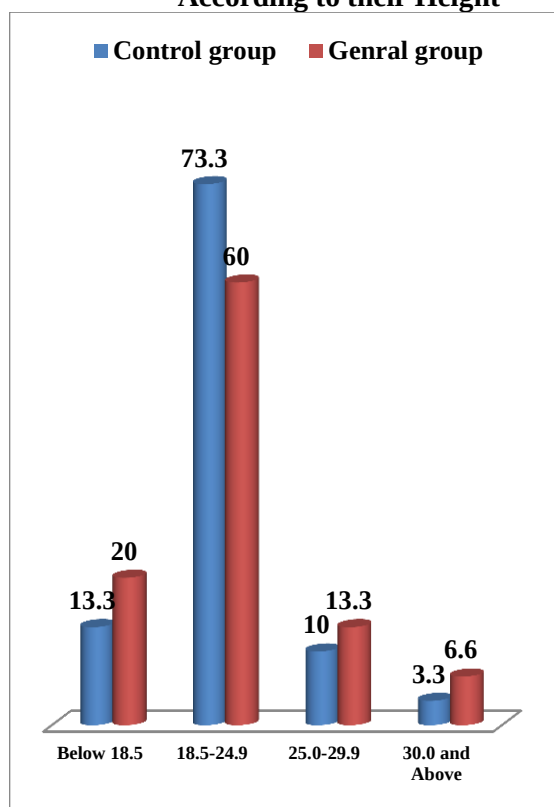


Fig. No. 16 Distribution of Respondents According to their Body Mass Index

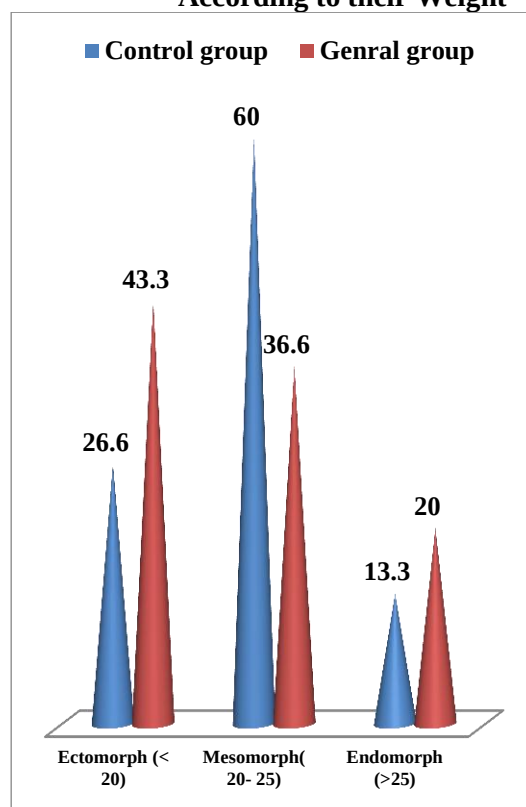


Fig. No. 17 Distribution of Respondents According to their Body Somatotypes

4.2 Ergonomic Evaluation of Farm Women performing the maize shelling activity

Ergonomic Evaluation of maize shelling activity was carried out to know the physiological workload of the female workers in traditional method and University developed maize sheller.

Table 4.3. Showed the ergonomic evolution of farm women while performing maize shelling activity, traditional and University developed maize sheller. Analysis of ergonomic data, indicated that the average resting heart rate was calculated to be (84.44 b.m^{-1}) and average working heart rate (93.07 b.m^{-1}) were quite high in traditional maize shelling activity as compared to the Univ. developed maize sheller (83.50 b.m^{-1}) and (92.79 b.m^{-1}) respectively. On average 0.94 b.m^{-1} (1.11 per cent) reduction was observed in resting heart rate and 0.91 b.m^{-1} (10.95 per cent) reduction was noted in working heart rate of women while working with Univ. developed maize sheller. In traditional method, the average heart rate of recovery (86.64 b.m^{-1}) and average energy expenditure (6.07 KJ m^{-1}) were found higher than the Univ. developed maize sheller i.e. 87.21 b.m^{-1} and 6.04 KJ m^{-1} respectively. Further, analysis of results revealed that average cardiac cost of work was found the highest (150.52) and it was (24.82**) noted to be significant at 1% level of significance. Total cardiac costs of work (172.51) and physiological costs of work (9.76) were found to be the highest in traditional method. The per centage reduction in total cardiac cost of work came to be 56.15 per cent and (-78.27 %) reduction seen women's in physiological costs of work, while performing maize sheling with traditional method and University developed maize sheller. Total cardiac cost of work (13.82**) and physiological cost of work (-8.25**) was noted to be significant at 1% level of probability. This finding more or less similar with Badiger *et al.* (2006) who have reported that physiological cost of work was noted as lesser while worked with the improved weeder twin wheel hoe (13.15 beats/min) and also for grubber weeder (18.74 beats/min) compared to the traditional method of weeding.

Table 4.3 Ergonomic Evaluation of Farm Women Performing Maize Shelling

(n=30)

Physiological Parameters	Traditional method (mean $\pm$ SD)	Univ. developed method (mean $\pm$ SD)	Significant reduction in UDMS over TM	t-test
Average resting heart rate (b.m ⁻¹)	84.44 $\pm$ 9.10	83.50 $\pm$ 9.53	0.94 (1.11)	0.34
Average working heart rate (b.m ⁻¹)	93.07 $\pm$ 9.2	92.79 $\pm$ 9.96	0.91 (0.95)	0.11
Average recovery heart rate (b.m ⁻¹)	86.64 $\pm$ 9.48	87.21 $\pm$ 9.39	-0.57 (-0.65)	-0.22
Average energy expenditure (kj.m ⁻¹)	6.07 $\pm$ 1.46	6.04 $\pm$ 1.59	0.03 (0.49)	0.09
Average CCW (beats)	150.52 $\pm$ 21.43	39.34 $\pm$ 11.30	111.18 (73.86)	24.82^{**}
Average TCCW (beats)	172.51 $\pm$ 30.41	75.65 $\pm$ 20	96.86 (56.15)	13.82^{**}
Average PCW (beats)	9.76 $\pm$ 1.63	17.40 $\pm$ 4.45	-7.64 (-78.27)	-8.25^{**}

* Significant at 5% level of Probability

** Significant at 1% level of Probability

4.2.1 Postural Inclination Analysis of Farm Women Performing Maize Shelling.

Postural analysis can be a powerful technique for assessing work activities. The risk of musculoskeletal injury associated with the recorded posture(s), in the context of a full ergonomic workplace assessment, can be a major factor for implementing change, so the availability of task-sensitive field techniques is of great assistance for the ergonomics practitioner.

Table 4.4 Postural Inclination Analysis of Farm Women while Performing Maize Shelling:

n=30

Particulars	Trunk, Neck, Legs	Upper arms, Lower arms, Wrists	Grand Score	Final Score	Risk level	Action Category
Traditional Method	3	8	7	8	High	Necessary action is required soon
Univ. Developed Maize Sheller	4	4	6	7	Medium	Necessary action is required

Analysis of posture Table- 4.4 shows the working postures of farm women while performing maize shelling activities. In case of traditional method farm women adopted working posture were under high risk category on the basis of REBA score i.e 8 where is necessary action is required soon. While University developed maize sheller farm women adopted working posture were under medium risk category on the basis of REBA score i.e 7 where is necessary action is required.

4.2.2 Postural Changes of Farm Women in Maize Shelling.

Postural change was measured by simply counting the number of times the respondent changes the postures. At the end of work, the total number of postural changes viz; standing, sitting and bending while performing the maize shelling activities done by the respondent were counted and documented.

Table. 4.5 Frequency Distribution of Postural Changes of Farm**n=30**

Frequency	Type of posture		
	No. of Sitting	No. of Standing	No. of Bending
Minimum	1	25	25
Maximum	3	28	28
Mean $\pm$ SD	1.33 $\pm$ 0.78	26.13 $\pm$ 1.13	26.13 $\pm$ 1.13

Frequency of postural change during the activity maize shelling activity was recorded during the experiment. Minimum postural change for sitting was found to only one time and maximum postural change for sitting was noted to be three times. The minimum postural change for standing and bending was came to be 25 times and the maximum postural change for standing and bending was 28 times. On an average postural change was occurred due to standing and bending posture of women while performing maize shelling activity was the mean value came to be 26.13 (Table 4.5 and Plate 6) and sitting posture of women while performing maize shelling activity was the mean value came to be 1.33. Sitting position was only used in traditional method of maize shelling while standing and bending positions was used in University Developed maize Sheller. It can be concluded that most of the maize shelling farm women's experienced this difficult activity as due to involvement of repetitive body movements and many postural changes during maize shelling. These finding more or less similar with Zender *et.al.* (2007) who observed that weeding is performed in standing position by using weeder-I and weeder-II it eliminates postural stress *by* reducing angle of deviation was noticeable. Field trials revealed that weeder-I functions very efficiently with higher coverage of land. Hence, weeder-I was recommended for efficient performance of weeding.

4.2.3 Grip Strength of Farm Women in Maize Shelling :

Grip fatigue for the selected activities was measured as a percentage reduction in grip strength. More the reduction in the grip strength was taken as the grip fatigue for the selected activities. Change in grip strength while performing the maize

shelling activity with both traditional and improved method has been shown in table.4.6 (Plate 5).

Table.4.6 Grip Strength of Farm Women in Maize Shelling

n=30

Parameters	Traditional Method		Univ. Developed Maize Sheller	
	Left Hand	Right Hand	Left Hand	Right Hand
Before work	12.54	17.85	12.63	17.55
After work	10.68	15.87	10.85	16.16
Per cent age change in grip strength	14.32	11.11	13.18	8.26
Per cent age change in left hand grip strength Univ. developed over traditional method.			1.14	
Per cent age change in right hand grip strength Univ. developed over traditional method.			2.85	

a. Left Hand :

In traditional method, the per cent age change in left hand grip strength was 14.32 after maize shelling activity and in University developed maize sheller per cent age change in the grip strength of the left hands was 13.18 while performing the maize shelling activities. The grip strength of left hands was reduced in both the Traditional method and University developed maize sheller after maize shelling activity. But the per cent age change in Univ. developed maize sheller over traditional method reduction in left hand grip strength was observed to be lower 1.14 in University developed maize sheller as compared to traditional method.

b. Right Hand:

In traditional method the per cent age change in grip strength of the right hand was calculated as to 11.11 after maize shelling activity performed and in University developed maize sheller per cent age change in the grip strength of the right hand was found to be 8.26, while performing the maize shelling activities. The grip strength of right hand was reduced after maize shelling activity in both the Traditional method



Reading of Respondents Grip Strength during Research Period



Reading of Respondents Weight during Research Period



Reading of Respondents Blood Pressure and Heart Rate during Research Period



Measurement of Respondents Height during Research Period

Plate :5 Researcher Engaged in Taking Anthropometric and Physiological data by the Respondents



Bending



Bending



Standing

**Plate :6 Different Type of Posture Adopted by Farm Women in Maize Shelling
in University Developed Maize Sheller**

and Univ. Developed maize sheller. But the per cent age change 2.85 was found University developed maize sheller over traditional method with the reduction in right hand grip strength which was observed to be lower in University developed maize sheller as compared to traditional method.

The results of the present study is in consonance with the study conducted by Hasalkar *et al.* (2007) while performing the top dressing fertilizer activity.

4.2.4 Musculoskeletal Disorders and Extent of Musculoskeletal Problem of Farm Women in Maize Shelling.

The musculoskeletal problems and symptom frequency score while performing the maize shelling activity in traditional method and University developed maize sheller.

Table 4.7 Musculoskeletal Disorders Faced by Farm Women in Maize Shelling

n=30

S. No.	Upper Extremities	Maize Shelling Method			
		Traditional Method		Univ. Developed Maize Sheller	
		Frequency	Percentage	Frequency	Percentage
1.	Neck	25	83.3	3	10.0
2.	Trunk	28	93.3	4	13.3
3.	Legs	30	100.0	8	26.7
4.	Upper Arms	27	90.0	9	30.0
5.	Lower Arms	28	93.3	7	23.3
6.	Wrists	30	100.0	13	43.3
7.	Shoulder	29	96.7	7	23.3
8.	Finger	30	100.0	8	26.7
9.	Upper Back	30	100.0	12	40.0
10.	Lower Back	27	90.0	14	46.7

Table 4.8 Extent of Musculoskeletal Problem of Farm Women in Maize Shelling**n=30**

Upper Extremities	Maize Shelling Method									
	Traditional Method					Univ. Developed Maize sheller				
	1	2	3	4	5	1	2	3	4	5
Neck	-	11 (36.6)	12 (40.0)	2 (6.6)	-	2 (6.6)	1 (3.3)	-	-	-
Trunk	-	2 (6.6)	15 (50.0)	10 (33.3)	1 (3.3)	-	3 (10.0)	1 (3.3)	-	-
Legs	-	-	10 (33.3)	16 (53.3)	4 (13.3)	2 (6.6)	5 (16.6)	1 (3.3)	-	-
Upper Arms	3 (10.0)	6 (20.0)	15 (16.6)	3 (10.0)	-	3 (10.0)	6 (20.0)	-	-	-
Lower Arms	2	6 (20.0)	16 (53.3)	4 (13.3)	-	2 (6.6)	5 (16.6)	-	-	-
Wrists	-	0	2 (6.6)	24 (80.0)	4 (13.3)	1 (3.3)	11 (36.6)	- (3.3)	-	-
Shoulder	-	5 (16.6)	8 (26.6)	16 (56.6)	-	3 (10.0)	4 (13.3)	-	-	-
Finger	-	0	8 (26.6)	22 (73.3)	-	7 (23.3)	1 (3.3)	-	-	-
Upper Back	-	1 (3.3)	10 (33.3)	16 (53.3)	3 (10.0)	3 (10.0)	9 (30.0)	-	-	-
Lower Back	3 (10.0)	1 (3.3)	17 (56.6)	14 (46.6)	5 (16.6)	2 (6.6)	11 (36.6)	1 (3.3)	-	-

With the help of the body map, musculoskeletal problems experienced by farm women were evaluated while performing the maize shelling activity in the traditional method presented in Table 4.7 and 4.8. Table 4.7 shows that all women expressed pain in their leg, wrist, finger, upper back and lower back 96.7 per cent of the selected farm women who performed the maize shelling activity had pain in shoulder. Approximately 90 to 93.3 per cent farm women suffered from problem of upper arm, followed by pain in lower arm and trunk. From table 4.8 it was observed that in traditional method major musculoskeletal problems in maize shelling activity as reported by majority of selected farm women were severe pain in wrist (80%), finger (73.3%), shoulder (56.6%), leg (53.3%) and upper back (53.3%). It is also clear from the table that farm women experienced moderate pain in lower back (56.6%), lower back (53.3%), trunk (50%) and neck pain (40%). Minimum number of farm women experienced light pain in the upper arms.

Maize shelling activity in an improved method presented in Table 4.7 and 4.8. Table 4.7 shows that majority of farm women expressed pain in their wrist, upper back and lower back 40-46.7 per cent of the selected female farmers who performed the maize shelling activity. Approximately 23.3 to 30% of farm women suffered from lower arm and shoulder problem, followed by pain in the leg, finger and upper arm. From table 4.8, it was observed that major musculoskeletal problems in maize shelling activity were moderate pain in lower back (36.6%), wrist (36.6%) and upper back (30 %), upper arm (20%), leg (16.6%) and shoulder (13.3%) in improved method as reported by selected farm women followed by (23.3 %) farm women experienced light pain in the finger.

It can therefore be concluded from the Table 4.8 that in the case of wrist, finger, leg, upper back, lower back and shoulder, the maximum musculoskeletal problems of farm women while performing maize shelling activity with traditional method were severe pain. Maximum farm women experienced musculoskeletal problems in the neck, trunk, upper arm and lower arms due to unnatural body posture and repetitive hand movements while performing maize shelling activity. In the case of improved method, farm women's maximum musculoskeletal problems were moderate pain in the lower back, wrist and upper back. Maximum female farmers experienced musculoskeletal problems in the leg, upper arm, lower arm and shoulder due to many postural changes and repetitive body movements while performing maize shelling activity.

These findings can be substantiated with Awasthi *et.al* (2017) who also found that the manual maize shelling is moderate heavy work but it can be lightened by the use of maize sheller. Moderate to severe pain is reported in wrist and fingers in manual shelling while very light to light pain was reported in wrist and no pain in fingers.

4.2.5 Assessment of Feeling of Exhaustion and Difficulty Perception while Performing the Maize Shelling.

Assessment of feeling of exhaustion and difficulty perception while performing maize shelling activity by two methods such as traditional method and University developed maize sheller was carried out and data is presented here with under following headings.

Table.4.9 Extent of Exhaustion Expressed by Farm Women in Maize Shelling
n=30

Methods of Maize Shelling	Feeling of exhaustion (Mean $\pm$ SD)	Reduction/Increase Traditional Vs Univ. Developer Maize sheller	t-values
Traditional Method	4.23 $\pm$ 0.76	2.7	15.0**
Univ. Developed Maize Sheller	1.53 $\pm$ 0.49	(63.82)	

Note: Figures in Parenthesis indicates percentage, ** Significant at 1% level of significance

Table 4.9 indicated the farm women's feeling of exhaustion while performing maize shelling activity through the use of traditional and improved methods. The mean score of feeling exhausted by traditional method in maize activity was found higher (4.23) than the mean score of feeling exhausted by improved method (1.53). 63.82 per cent of reduction in mean score of feeling of exhaustion was noted in maize shelling activity done with the University developed maize sheller compared to traditional method. Statistical analysis revealed significant results in case of maize shelling activity performed by the traditional and improved method as t-value came to 15.0** at 1% level of significance. The selected farm women felt significantly less exhaustion when maize shelling was performed by improved method. Hence, it can be concluded that University developed maize sheller is quite suitable to the farm women.

Table.4.10 Difficulty Perception in Maize Shelling Performing by Farm Women
n=30

Methods of Maize Shelling	Opinion Regarding Difficulty Level (Mean $\pm$ SD)	Reduction/Increase Traditional Vs Univ. Developer Maize sheller	t-values
Traditional Method	3.46 $\pm$ 0.66	16	10.0**
Univ. Developed Maize Sheller	1.86 $\pm$ 0.49	(46.24)	

Note: Figures in Parenthesis indicates percentage ** Significant at 1 % level

Farm women's perception of difficulties in traditional and improved method while performing maize shelling activity is presented in Table 4.10 and farm women's

perception of difficulties in improved method handling. The results revealed that, in traditional method, the mean score of difficulty perception in maize shelling performed by the respondents was (3.46) which was more compared to the mean score of difficulty perception (1.86) in improved method. Further, It was found that the perception of farm women's difficulties reduced by 46.24 per cent in case of University developed maize sheller compared to traditional method. With the application of t-test, the traditional method was compared with the improved. Further, the t-value came to be 10.0** significant at 1% level of significance. Thus, it can be concluded that farm women's perception of difficulty was less in improved method compared to traditional method. In traditional method, the level of perception of difficulties was higher because traditional maize shelling activities are not only drudgeries, but also time consuming.

4.2.6 Opinion of Farm Women in Maize Shelling Activities.

A given opinion may deal with subjective matters in which there is no conclusive finding, or it may deal with facts which are sought to be disputed by the logical fallacy that one is entitled to their opinions

4.6.1 Opinion of Farm Women in Traditional Maize Shelling

Opinion of farm women for maize shelling activities through traditional methods. It computed for all the sub-component of traditional methods and has been presented in Table 4.11. To assess the impact of impact of maize shelling of traditional methods of farm women Opinion about maize shelling respondents was studied. On the basis of calculated of statements given by the respondents was classified into three categories i.e. Low (< 41.9), Medium (41.9 - 47.5) and High (> 47.5) level of Opinion which is presented here in Table 4.11.

Table 4.11. Opinion of Farm Women in Traditional Maize Shelling

n=30

S.No	Category	Frequency	Percentage
1.	Low (Mean-SD)	4	13.3
2.	Medium(Mean±SD)	20	66.7
3.	High (Mean+SD)	6	20

It is evident from Table- 4.11 that out of thirty respondents maximum respondents (66.7 %) had medium level of opinion score ranging (41.9 - 47.5), which clearly indicated that they possessed low level of opinion toward maize shelling 13.3 per cent respondents have opinion score ranging from (< 41.9) followed by 20 per cent respondents high level of opinion had score (> 47.5) towards maize shelling.

4.2.6.2 Opinion of Farm Women in University Developed Maize Sheller

Opinion of farm women for maize shelling activities through University developed maize sheller. It computed for all the sub-component of University developed maize sheller and has been presented in Table 4.12. To assess the impact of impact of maize shelling of University developed maize sheller of farm women Opinion about maize shelling respondents was studied. On the basis of calculated of statements given by the respondents was classified into three categories i.e. low (< 45.4), medium (45.4 – 51.1) and high (> 51.1) level of Opinion which is presented here in Table 4.12

Table 4.12 Opinion of Farm Women in University Developed Maize Sheller

n=30			
S.No	Category	Frequency	Percentage
1.	Low (Mean-SD)	5	16.7
2.	Medium (Mean $\pm$ SD)	22	73.3
3.	High (Mean+SD)	3	10

It is evident from Table- 4.12. that out of thirty respondents maximum respondents (73.3 %) had medium level of opinion score ranging (45.4 – 51.1), which clearly indicated that they possessed medium level of opinion toward maize shelling. 16.7 per cent respondents have opinion score ranging from (< 45.4) indicating that they possessed low level of opinion followed by ten per cent respondents high level of opinion had score (> 51.1) towards maize shelling.

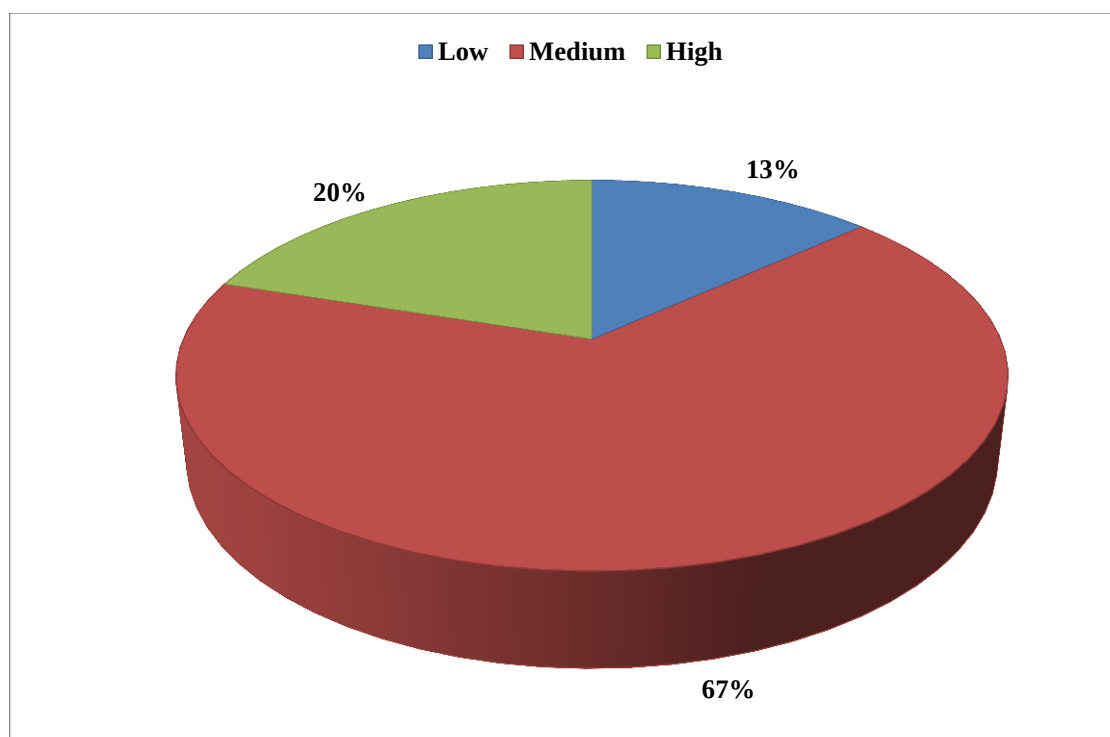


Fig. No. 18 Distribution of Respondents According to their Opinion Regarding Traditional Maize Sheller

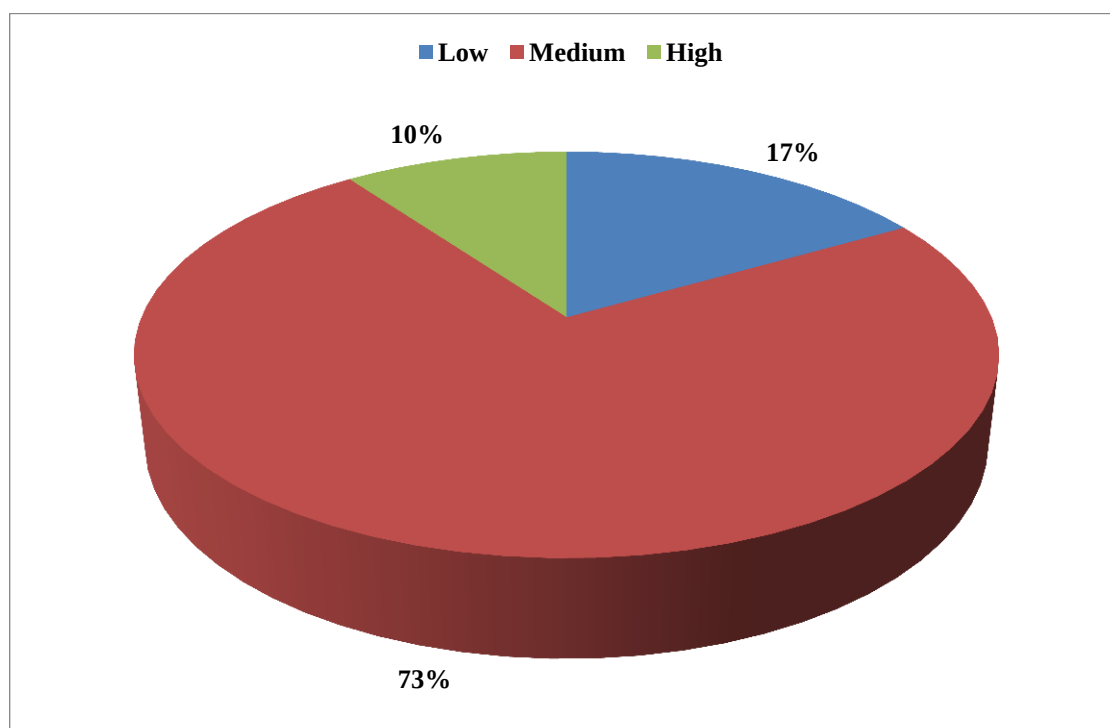


Fig. No. 19 Distribution of Respondents According to their Opinion Regarding Univ. Developed Maize Sheller

4.2.7 Time Management Practices of the Farm Women

The analysis of data in table 4.13 indicated the time management practices of Women's involvement in agriculture, their household and other work activities i.e, animal housekeeping, marketing etc.

Agricultural Works:

Data showed that out of the total sample maximum respondents (38.3 %) worked for agriculture activities for 1-3 hours followed by 35 per cent respondents devoting 7-9 hours to agricultural work and only 26.6 per cent women use to spend 4-6 hours for agricultural works. Under the control group maximum respondents (43.3 %) were working for 1-2 hours followed by the women's (33.3 %) were working for 7-9 hours (23.3 %) devoting 4-6 hours to agricultural work. In the general group maximum respondents (36.7 %) were working for 7-9 hours (33.3 %) followed by the women working for 1-3 hours and only 23.3 per cent respondents were devoting 4-6 hours to agricultural work.

Participation in maize shelling activity:

Data showed that maximum respondents (35 %) devoted 2-4 hours followed by (33.3 %) respondents participated for up to 2 hours while very fewer respondents (25.0 %) participated for 4-6 hours due to the fact that traditional maize shelling activity is highly prone to drudgery. Maximum respondents in the control group (36.7 %) participating for maize shelling activity followed by respondents (33.3 %) participating for 2-4 hrs and respondents (26.6%) for 4-6 hrs. In case of maize shelling activity maximum respondents of the general group (36.7 %) were worked for 2-4 hrs followed by (30 %) respondents participated for 0-2 hrs and 23.3 per cent respondents worked for 4-6 hrs 10 per cent participated 6-8 hrs for maize shelling.

Involvement in maize shelling:

Data showed that out of the total sample maximum respondents (51.6 %) practiced in maize shelling since last 10-15 years followed by (26.6%) respondents involved in maize shelling for 5-10 years followed by the less respondents (21.6 %) for 1-4 years. Maximum respondents in the control group (53.3 %) involving maize shelling for 10-15 years followed by (23.3 %) respondents involving maize shelling for 5-10 years and (23.3 %) respondents involving maize shelling for 1-4 years. For general group maximum 50 per cent respondents practiced the maize shelling for 10-

15 years followed by 30 per cent respondents involved in maize shelling for 5-10 years whereas only 20 per cent respondents were involved for maize shelling for 1-4 years.

Household work:

Table 4.13 highlighted that 58.3 per cent of respondents spent 4-6 hours per day on household work followed by 44.6 per cent women spent 1-3 hours per day in household work. In the case of control group, the majority of respondents (53.3 %) were spending 4-6 hours per day in their household work, followed by (46.7 %) spent 1-3 hours per day in household work. While 63.3 per cent respondent's general group were spending 4-6 hours in household work.

Leisure:

On overall basis a large number of respondents (81.6 %) devoted 1-3 hours for leisure time per day in different group. In the control group, 93.3 per cent of the maximum respondents in the control group were spending time for leisure, while in the general group 70 per cent of women were spent 1-3 hours for leisure.

Sleeping:

The data presented in Table 4.13 revealed that the majority of respondents (83.3 %) spent 7-9 hours per day sleeping. In the case of control group, the majority of respondents (80 %) spent 7-9 hours a day for sleeping. In the case of a general group, majority of respondents (86.7 %) spent 7-9 hours per day for sleeping.

Other work:

The analysis of data in Table 4.13 data indicated the time management practices for other works performed by the women. The data showed that the majority of respondents (53.3 %) utilized 4-6 hours for other work i.e animal rearing, entertainments, personal care, followed by the respondents (46.6 %) giving only 1-3 hours. In the case of a control group, the majority of respondents (53.3%) gave 1-3 hours for other works followed by 46.7 per cent respondents utilized only 4-6 hours for other works i.e animal rearing, entertainment. In general group, the majority of respondents 60 per cent spent 4-6 hours for performing other work followed by 40 per cent respondents who gave only 1-3 hours in general group.

Table.4.13 Time Management Practices of the Farm Women

(n=60)

S.No.	Parameters	Particulars	Control Group (F & P)	General Group (F & P)	Total (F & P)
1.	Agricultural Work	1-3 hrs	13 (43.3)	10 (33.3)	23 (38.3)
		4-6 hrs	7 (23.3)	9 (30.0)	16 (26.6)
		7-9 hrs	10 (33.3)	11 (36.7)	21 (35.0)
2.	Participation in maize shelling activity	0-2 hrs	11 (36.7)	9 (30.0)	20 (33.3)
		2-4 hrs	10 (33.3)	11 (36.7)	21 (35.0)
		4-6 hrs	8 (26.6)	7 (23.3)	15 (25.0)
		6-8 Hrs	1 (3.3)	3 (10.0)	4 (6.6)
3.	Involvement in maize shelling	1-4 years	7 (23.3)	6 (20.0)	13 (21.6)
		5-10 years	7 (23.3)	9 (30.0)	16 (26.6)
		10-15 years	16 (53.3)	15 (50.0)	31 (51.6)
4.	Household Work	1-3 hrs	14 (46.7)	11 (36.6)	15 (25.0)
		4-6 hrs	16 (53.3)	19 (63.3)	25 (41.6)
		7-9 hrs	-	-	-
5.	Leisure	1-3 hrs	28 (93.3)	21 (70.0)	49 (81.6)
		4-6 hrs	2 (6.7)	9 (30.0)	11 (18.3)
		7-9 hrs	-	-	-
6.	Sleeping	1-3 hrs	-	-	-
		4-6 hrs	6 (20.0)	4 (13.3)	10 (16.6)
		7-9 hrs	24 (80.0)	26 (86.7)	50 (83.3)
7.	Other work (Animal rearing, Stitching, Marketing)	1-3 hrs	16 (53.3)	12 (40.0)	28 (46.6)
		4-6 hrs	14 (46.7)	18 (60.0)	32 (53.3)
		7-9 hrs	-	-	-

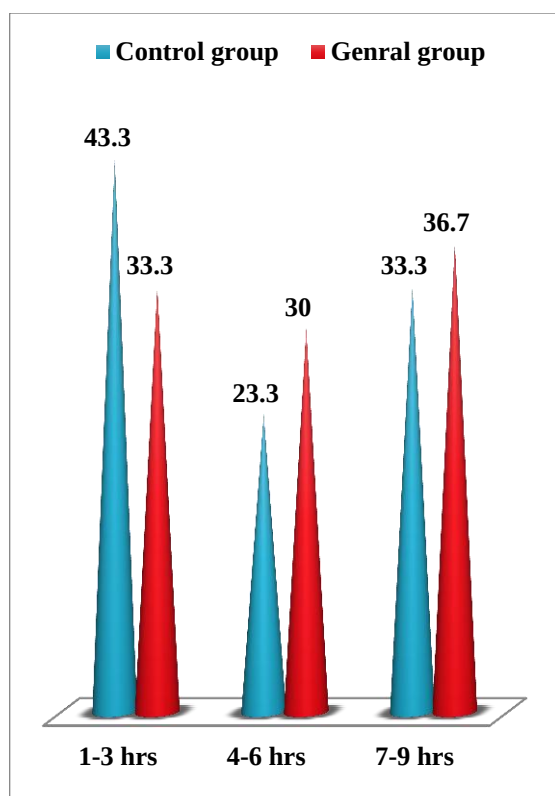


Fig. No. 20 Distribution of Respondents According to their Agricultural Work

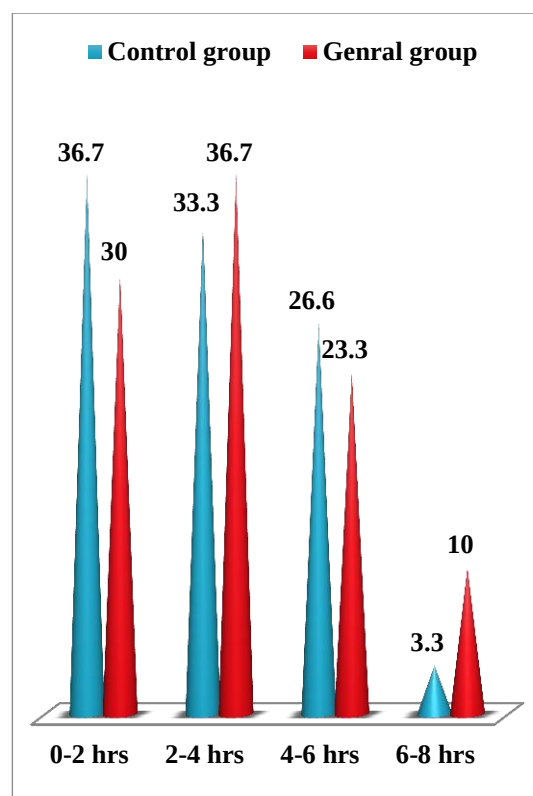


Fig. No. 21 Distribution of Respondents According to their Participation in Maize Shelling

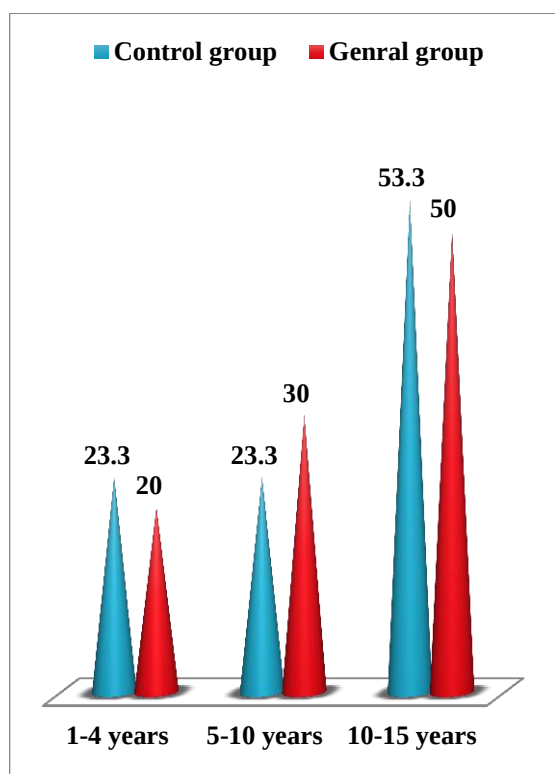


Fig. No. 22 Distribution of Respondents According to their Involvement in Maize Shelling

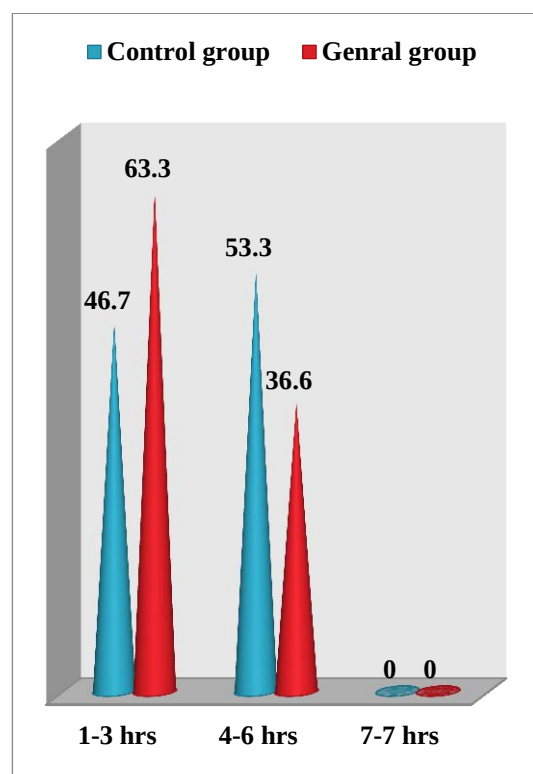


Fig. No. 23 Distribution of Respondents According to their Household Work

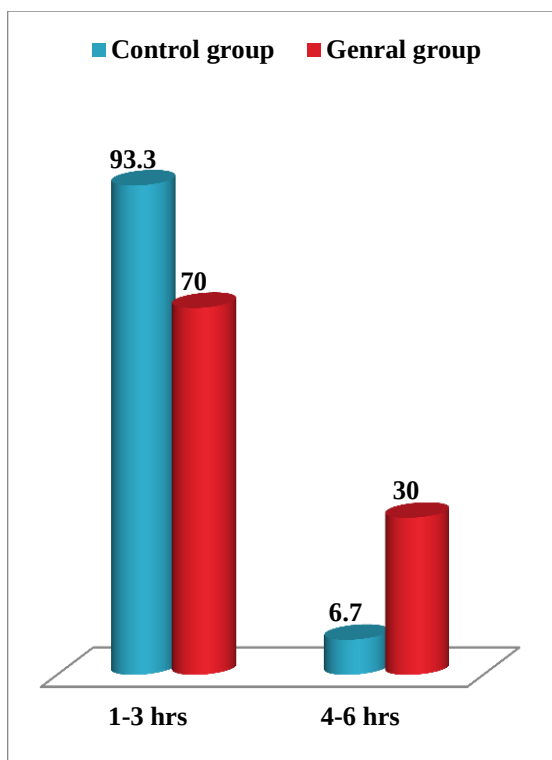


Fig. No. 24 Distribution of Respondents According to their Leisure

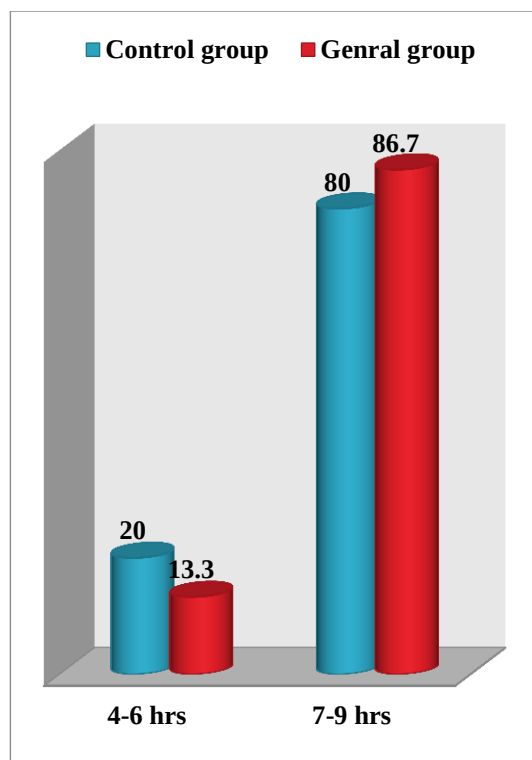


Fig. No. 25 Distribution of Respondents According to their Sleeping

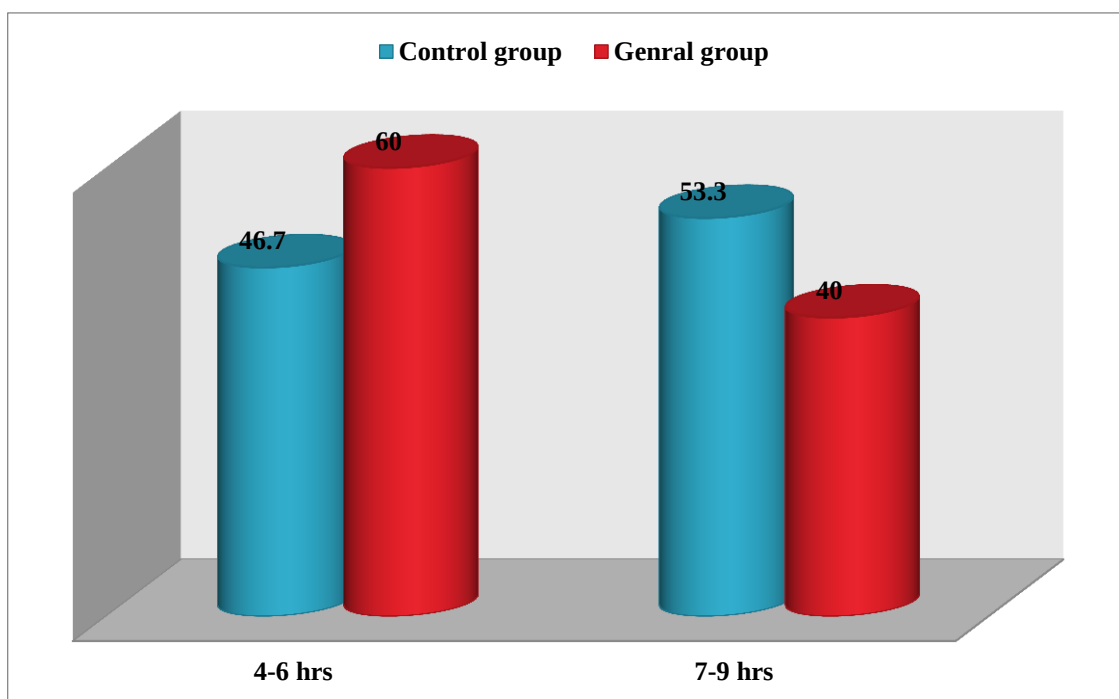


Fig. No. 26 Distribution of Respondents According to their Other Work

4.3 Comparative Evaluation of Efficiency of University Developed Maize Sheller and Traditional Method of Maize Shelling

Traditionally shelling of maize are being done either by threshing cobs or removal of seeds by hand. Studies have revealed that the farm activities are time and labour intensive, monotonous, repetitive and more drudgery prone are generally performed by women. Since all the operations are done manually they cause considerable physical and mental fatigue and other health problems. The root cause of their sufferings is unawareness or ignorance about improved technologies, age-old methods of doing the work, inappropriateness of the technology and attitudinal constraints such as innate conservatism and resistance to change. Study was planned with objective to compare efficiency of University Developed Maize Sheller and Traditional Method of Maize Shelling.

4.3.1 Physical Characteristics of Maize

A part from the machine parameters physical properties of maize also affects shelling efficiency of machine as well as the women performing maize shelling

Table 4.14 Different Physical Characteristics of Maize during Shelling Activity

S.No.	Particulars	Mean Value
1.	Variety of crop	NK6607 Corn
2.	Length of maize cob (cm)	17.59
3.	Circumference of maize cob (cm)	4.70
4.	Weight of Maize cobs (gm)	191.2
5.	Moisture content of maize cobs (db)	16.12
6.	Weight of 1000 Grain (gm)	302.2

The variety used by maize cobs was NK6607 Corn in Maize shelling in both methods. The overall average length of cobs was noted 17.59 cm and the circumference of cobs was calculated 4.70 cm. The average weight of cobs was noted 191.2, the weight of 1000 grains was calculated 302.8 gm and the moisture content of maize cobs was 16.12 db.(Plate 7& 8).



Measurement of Single Maize Cob



Measurement of 1000 gm of Grains



Researcher Engaged in Taking Weight of Single Cobs grain



Taking Moisture of Maize Grain

Plate :7 Researcher Engaged in Taking data of Crop Parameters

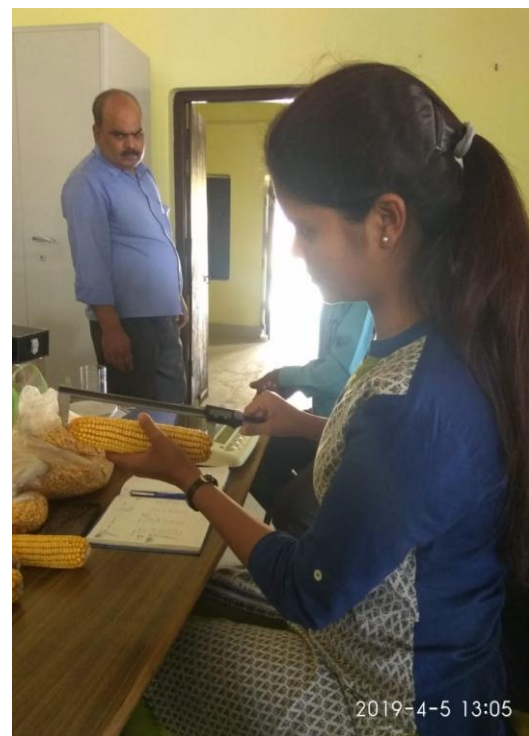


Plate :8 Researcher Engaged in Measuring Crop Dimensions and Length

4.3.2 Efficiency of University Developed Maize Sheller over Traditional Method

Efficiency signifies a level of performance that describes using the least amount of input to achieve the highest amount of output.

Table 4.15 Efficiency of University Developed Maize Sheller over Traditional Method

S.No	Particulars	Traditional Method	Univ. Developed Maize Sheller
1.	Amount of maize shelling	5 kg	5 kg
2.	Output (kg/hr)	16.97	70.20
3.	Visual damage losses (% by Weight)	0.63	1.36
4.	Un Threshed grain (% by Weight)	0.02	0.30
5.	Time spent to shell 26 cobs (min)*	17.68	4.28
6.	Shelling efficiency (%)	86.15	87.73

*Wt. of 26 cobs is equal to 5 kg. for both the treatments

The quantity of maize cobs provides by 5 kg per respondents. Higher output of machine value 70.20 (kg/hr) compared to traditional method 16.97 (kg/hr). Compared to the machine, the output of the traditional method is very low. It could be very drudgery prone activity and time consuming due to the traditional method. The average loss of visual damage was found in traditional method 0.63 per cent and machine value 1.36 per cent. Unthreshed grain percentage of the traditional method was 0.02 per cent and machine value was 0.10 per cent respectively. Average time taken for removing grain from five kg maize cobs was 17.68 minutes in case of traditional methods and by use of University developed Maize Sheller it was only 4.28 minutes. And the overall shelling efficiency of the traditional method was found to be 86.15 per cent, slightly less than the shelling efficiency of the machine value of 87.73 per cent. This finding more or less supported by Awasthi *et.al* (2017) who reported that whereas only 13 kg grain was removed by maize sheller whereas only 7.5 kg grain was removed in one hour by manual shelling. Average time taken for removing grain from one corn was 93 seconds in case of manual shelling and by use of maize sheller it was only 40 seconds.

4.3.3 Field Acceptability of University Developed Maize Sheller

The field acceptability of University developed maize sheller was assessed after ergonomic evaluation of the technology. It was assessed with the help of statement containing convenience, work stress, tool factor and field acceptability. On the basis of calculated of statements given by the respondents was classified into three categories i.e. low (< 39.9), medium ($39.9 - 45.5$) and high (> 45.5) level of Opinion which is presented here in Table 4.12

Table 4.16 Field Acceptability of University Developed Maize Sheller

n=30

S.No.	Category	Frequency	Percentage
1.	Low (Mean-SD)	6	20
2.	Medium(Mean $\pm$ SD)	21	70
3.	High (Mean+SD)	3	10

It is clear from the Table. No. 4.16. that majority of respondents (70 %) possessed medium level of field acceptability of machine, which was followed by low level of acceptability of machine (20%) and only ten per cent farm women had high level of acceptability of University developed maize sheller, which focused that of majority of farm women accepted for the adoption of the University developed maize shelling machine for shelling of maize grown in their field.

Table 4.17 Coefficient of Correlation between Output of Traditional Method and University Developed Maize Sheller with Selected Independent Variables**n=30**

S.No.	Independent variable	Value 'r'					
		Output (kg/hr)					
		TM	UDMS	TM	UDMS	TM	UDMS
1	Age	0.263	0.499	0.199	0.549	0.182	0.364
2	Family Type	0.700*	0.177	0.644*	0.198	0.346	0.142
3	Family Size	0.545	0.693*	0.242	0.659*	0.127	0.028
4	Education	0.382	0.194	0.514	0.429	0.537	0.540
5	Family Education Status	0.430	0.032	0.600	0.609	0.169	0.068
6	Caste	0.019	0.149	0.311	0.029	0.093	0.004
7	Occupation	0.186	0.372	0.106	0.290	0.555	0.315
8	Income	0.516	0.231	-0.644*	0.067	0.451	0.031
9	Participation	0.294	-0.017	0.457	0.080	0.144	0.423
10	Height	0.036	0.650*	0.312	0.351	0.038	0.576
11	Weight	0.397	0.067	0.105	0.091	0.453	0.634*
12	BMI	0.400	0.540	-0.225	0.051	0.547	0.562
13	Postural inclination	-0.080	-0.074	0.550	0.238	-0.244	-0.532
14	AHR _{res.}	0.209	0.493	0.463	0.385	-0.302	0.118
15	AWHR	0.249	0.439	0.417	0.422	0.386	0.116
16	AHR _{rec.}	0.206	0.435	0.438	0.391	0.400	0.070
17	SBP _{before}	0.291	-0.768**	0.371	-0.011	0.320	-0.067
18	DBP _{before}	0.134	-0.775**	0.435	-0.398	-0.490	0.425
19	SBP _{after}	0.303	-0.726*	0.199	0.215	-0.277	-0.073
20	DBP _{after}	0.250	-0.769**	0.150	0.389	-0.531	0.472
21	Moisture	-0.046	0.506	0.405	0.161	0.324	0.005
22	Time	0.996**	0.901**	0.998**	0.988**	0.995**	0.987**

** Significant at 5% level

* Significant at 1% level

TM- Traditional Method

UDMS- University Developed Maize Sheller

AHR_{res.}- Average resting heart rate

AWHR- Average working heart rate

AHR_{rec.}- Average recovery heart rate

Table no. 4.17 shows that coefficient of co-relation between output of traditional method of maize shelling and University developed maize sheller with the selected independent variables. Output capacity was taken as dependent variables, which were correlated with 22 selected independent variables. Further, quantities of shelled maize were measured in both traditional method and University developed maize sheller for 3 different age groups i.e., 21-30 years, 31-40 years and 41-50 years respectively.

The analysis of results revealed that in the age group of 21-30 years the independent variables such as family type (0.700*) was found to be significant at 5% level of probability. Whereas time (0.996**) came to be significant at 1% level of probability. In University developed Maize Sheller result shows that the independent variables such as family size (0.693*) and height (0.650*) was found to be significant at 5 % level of probability. Further after systolic blood pressure (-0.665*) came to be negatively significant at 5 per cent level of probability. Whereas the before systolic blood pressure (-0.768**), before diastolic blood pressure (-0.775**) and after diastolic blood pressure (-0.769**) came to be negatively significant at 1 per cent level of probability. Whereas, time (0.901**) came to be significant at 1 per cent level of probability.

The analysis of under the age group of 31-40 years the independent variables such as family type (0.644*) was found to be significant at 5 per cent level of probability and income (-0.644*) was found to be negatively significant at 5 per cent level of probability. While the time (0.988**) was noted to be significant at 1 percent level of probability. In the University developed maize sheller independent variable like family size (0.659*) was found to be significant at 5% level of probability.

Under age group of 41-50 years farm women, it was revealed that the independent variables such as time (0.995**) was found to be significant at 1% level of probability, while in University developed maize sheller the independent variable weight (0.634*) was found to be significant at 5% level of probability. Whereas time (0.987**) was found to be significant at 1% level of probability.

Table 4.18 Coefficient of Correlation between Physiological Cost of Work of Traditional method and University Developed Maize Sheller with Selected Independent Variables

n=30

S.No.	Independent Variable	Value 'r'					
		Physiological Cost of Work					
		Age group 21-30 yrs		Age group 31-40 yrs		Age group 41-50 yrs	
		TM	UDMS	TM	UDMS	TM	UDMS
1	Age	0.281	0.321	0.222	0.484	0.338	0.666*
2	Family Type	0.023	0.305	0.026	0.855**	0.008	0.437
3	Family Size	0.670*	0.325	0.063	0.317	0.346	-0.046
4	Education	0.106	0.115	0.223	0.001	0.088	0.331
5	Family Education Status	0.305	0.187	0.136	0.207	0.015	0.181
6	Caste	0.018	0.217	0.111	-0.135	0.087	-0.039
7	Occupation	0.372	0.123	0.637*	0.303	0.664*	0.421
8	Income	0.049	0.206	0.043	0.449	0.730*	0.455
9	Participation	0.318	0.044	-0.301	-0.686*	0.103	-0.176
10	Height	0.684*	0.851**	0.237	0.027	0.147	-0.398
11	Weight	0.205	0.183	0.237	0.002	0.234	0.793**
12	BMI	-0.341	-0.121	0.182	0.002	0.136	-0.011
13	Postural inclination	-0.750*	-0.290	0.765**	-0.201	-0.285	0.083
14	AHR _{res.}	0.167	0.015	0.372	0.459	0.363	0.204
15	AHR	0.036	0.131	0.429	0.473	0.408	0.645*
16	AHR _{rec.}	0.025	0.113	0.436	0.103	0.473	0.778**
17	SBP _{before}	-0.444	-0.287	0.134	-0.318	-0.403	0.064
18	DBP _{before}	-0.280	-0.517	0.270	-0.410	-0.263	0.277
19	SBP _{after}	-0.419	-0.296	0.198	-0.406	-0.272	0.034
20	DBP _{after}	-0.303	-0.477	0.030	-0.146	-0.197	0.149
21	Moisture	0.052	0.398	0.121	0.012	0.069	0.482
22	Time	0.032	0.385	0.341	0.152	0.049	0.083

** Significant at 5% level

* Significant at 1% level

TM- Traditional Method

UDMS- University Developed Maize Sheller

AHR_{res.}- Average resting heart rate

AHR- Average working heart rate

AHR_{rec.}- Average recovery heart rate

Table no. 4.18 show the co-relation coefficient between the physiological/ cardiac cost of work (PCW) of farm women performing maize shelling with traditional method and University developed maize sheller and with selected independent variables. Physiological /cardiac cost of work (PCW) were taken as dependent variables which were correlated with 22 selected independent variables, with the 3 different age groups i.e., 21-30 years, 31-40 years and 41-50 years farm women.

The analysis of result revealed that in the age group of 21-30 years the independent variables such as family size (0.670*) and height (0.684*) was found to be significant at 5% level of probability. While in the traditional method of maize shelling the posture inclination (-0.750*) was found to be negatively significant at 5% level of probability. While in the case of University developed Maize Sheller result shows that the independent variables like height (0.851**) was found to be significant at 1% level of probability.

In age group of 31-40 years farm women, it was revealed that the independent variables such as occupation (0.637*) was found to be significant at 5% level of probability. While in the traditional method of maize shelling the posture inclination (-0.765**) was found to be negatively significant at 1% level of probability. While in the case of University developed Maize Sheller the independent variables like social participation (0.686*) was found to be significant at 5% level of probability. Also the family type (0.855**) was found to be significant at 1% level of probability.

The analysis of results highlighted in the case of age group 41-50 years, the independent variables such as occupation (0.664*) and income (0.730*) was found to be significant at 5% level of probability. While in University developed Maize Sheller the independent variable like age (0.666*) and working heart rate (0.645*) was found to be negatively significant at 5% level of probability. Also the weight (0.793**) and recovery heart rate (0.778**) was found to be significant at 1% level of understanding.

Table 4.19 Coefficient of Correlation between Shelling Efficiency of Traditional method and University Developed maize Sheller with Selected Independent Variables

S.No.	Independent variable	Value 'r'					
		Shelling Efficiency					
		Age group 21-30 yrs		Age group 31-40 yrs		Age group 41-50 yrs	
		TM	UDMS	TM	UDMS	TM	UDMS
1	Age	0.699*	0.257	0.023	0.537	0.196	0.448
2	Family Type	0.332	0.243	0.541	0.242	0.298	0.421
3	Family Size	0.092	0.236	0.564	0.172	0.192	0.118
4	Education	-0.082	0.572	0.115	0.378	0.102	0.175
5	Family Education Status	0.554	0.017	0.293	0.315	0.077	0.461
6	Caste	0.139	0.500	0.124	0.008	0.059	0.106
7	Occupation	0.350	0.548	0.019	0.040	0.204	0.347
8	Income	-0.174	0.225	0.226	0.255	0.073	0.387
9	Participation	0.496	0.283	0.189	0.015	0.173	0.548
10	Height	0.255	0.135	0.217	0.293	0.189	0.238
11	Weight	0.274	0.515	0.003	0.235	0.212	0.371
12	BMI	0.018	0.420	0.109	0.086	0.258	0.222
13	Postural inclination	-0.699*	0.029	0.018	-0.069	0.341	-0.162
14	AHR _{res.}	-0.528	0.516	-0.041	0.060	-0.050	-0.162
15	AWhR	-0.447	0.620	-0.098	0.002	-0.025	-0.146
16	AHR _{rec.}	-0.429	0.560	-0.049	0.210	-0.046	-0.162
17	SBP _{before}	0.384	0.036	0.139	0.407	0.301	0.279
18	DBP _{before}	0.146	0.208	0.030	0.347	0.072	0.082
19	SBP _{after}	0.558	0.027	0.315	0.404	0.210	0.161
20	DBP _{after}	0.227	0.042	0.211	0.084	0.174	0.171
21	Moisture	-0.694*	-0.667*	-0.120	-0.671*	-0.273	-0.470
22	Time	0.142	0.301	0.460	0.196	0.038	0.122

** Significant at 1% level

* Significant at 5% level

TM- Traditional Method

UDMS- University Developed Maize Sheller

AHR_{res.}- Average resting heart rate

AWhR- Average working heart rate

AHR_{rec.}- Average recovery heart rate

The analysis of data in Table no. 4.19 shows that co-relation between shelling efficiency of women performing maize shelling in traditional maize sheller and the University developed maize sheller with selected independent variables. Shelling efficiency was taken as dependent variable, which correlated with 22 independent variables. The data were taken from both traditional method and University developed maize sheller with three different age groups i.e., 21-30 years, 31-40 years, and 41-50 years Farm women.

Under 21-30 years age group farm women the independent variables such as age (0.699*) was calculated to be significant at 5% level of probability. The posture inclination (-0.699*) and moisture (-0.694*) was found to be negatively significant at 5% level of probability. While in University developed maize sheller results focused that the independent variable such as moisture (-0.667*) came to be significant at 5% level of probability.

The analysis of results pertaining to 31-40 years age group revealed that the independent variable was found to be non-significant with the shelling efficiency. In case of University developed maize sheller the independent variable as moisture (-0.671*) was found to be negatively significant at 5% level of probability.

Further, the analysis of results highlighted that in the case of age group 41-50 years farm women were found to be non-significant with the shelling efficiency in both the traditional and University developed maize shelling method.

Table 4.20 Coefficient of Correlation between Output of Traditional method and University Developed maize Sheller with Selected Independent Variables

n=30

S.No .	Independent variable	Value 'r'	
		Output (kg/hr)	
		Traditional Method	Univ. Developed Maize Sheller
1	Age	0.094	-0.394*
2	Family Type	0.031	0.162
3	Family Size	0.372*	0.377*
4	Education	-0.368*	0.493**
5	Family Education Status	0.015	0.098
6	Caste	0.129	0.138
7	Occupation	0.183	0.216
8	Income	-0.147	0.050
9	Participation	0.033	0.052
10	Height	0.005	0.561**
11	Weight	0.024	0.171
12	BMI	0.065	0.004
13	Postural inclination	0.031	0.171
14	AHR _{res.}	0.148	0.247
15	AWHR	0.094	0.244
16	AHR _{rec.}	0.092	0.263
17	SBP _{before}	0.083	-0.324
18	DBP _{before}	0.064	0.110
19	SBP _{after}	0.081	-0.253
20	DBP _{after}	0.095	0.036
21	Moisture	0.196	0.173
22	Time	0.995**	0.968**

****** Significant at 1% level

***** Significant at 5% level

TM- Traditional Method

UDMS- University Developed Maize Sheller

AHR_{res.}- Average resting heart rate

AWHR- Average working heart rate

AHR_{rec.}- Average recovery heart rate

Table no. 4.20 show that coefficient of co-relation between output capacity of traditional maize shelling and University developed maize sheller with selected independent variables. Output capacities were taken as dependent variable which correlated with 22 independent variables.

The analysis of results indicated that in the traditional method, the independent variables such as respondent's education (-0.368*) was found to be negatively significant at 5 per cent level of probability. While time (0.995*) was calculated to be significant at 1 per cent level of probability. In case of University developed maize sheller, the independent variable like family size (0.377*) was found to be significant at 5 per cent level of probability. Also the respondents education (0.493**) and height (0.561**) was noted to be significant at 1 per cent level of probability. While the time (0.968**) was found to be significant at 1% level of probability.

Table 4.21 Coefficient of Correlation between Physiological Cost of Work of Traditional method and University Developed Maize Sheller with Selected Independent Variables

n=30

S.No.	Independent variable	Value 'r'	
		Physiological Cost of Work	
		Traditional Method	Univ. Developed Maize Sheller
1	Age	0.016	0.040
2	Family Type	0.018	0.414*
3	Family Size	0.361*	0.190
4	Education	0.013	0.092
5	Family Education Status	0.111	0.100
6	Caste	0.011	0.004
7	Occupation	0.554**	0.113
8	Income	0.116	0.482**
9	Participation	0.048	-0.276
10	Height	0.377*	-0.057
11	Weight	0.187	0.078
12	BMI	0.009	0.464**
13	Postural inclination	-0.103	-0.102
14	AHR _{res.}	0.170	0.240
15	AHR _{rec.}	0.291	0.174
16	SBP _{before}	0.292	0.173
17	DBP _{before}	0.263	0.131
18	SBP _{after}	0.203	0.125
19	DBP _{after}	-0.235	-0.188
20	Moisture	-0.165	-0.126
21	Time	0.024	0.159
22		0.096	0.077

** Significant at 5% level

* Significant at 1% level

TM- Traditional Method

UDMS- University Developed Maize Sheller

AHR_{res.}- Average resting heart rate

AHR_{rec.}- Average recovery heart rate

Table no. 4.21 show the coefficient of co-relation between physiological/cardiac cost of work in traditional maize shelling and University developed maize sheller and with selected independent variables. Physiological/cardiac cost of work was taken as dependent variables, which correlated with 22 independent variables.

Further, the analysis of results highlighted that in the traditional method, the independent variables such as average working heart rate (0.442*) and average recovery heart rate (0.419*) was found to be significant at 5per cent level of probability. While occupation (0.536**) was found to be significant at 1 per cent level of probability. In case of University developed maize sheller, the independent variable like family type (0.368*) and income (0.431*) was noted to be significant at 5 per cent level of probability.

Table 4.22 Coefficient of Correlation between Output of Traditional Method and University Developed Maize Sheller with Selected Independent Variables

n=30

S.No.	Independent variable	Value 'r'	
		Efficiency	
		Traditional Method	Univ. Developed Maize Sheller
1	Age	0.096	-0.405*
2	Family Type	0.146	0.145
3	Family Size	0.123	0.161
4	Education	0.202	0.026
5	Family Education Status	0.242	0.271
6	Caste	0.174	0.008
7	Occupation	0.069	0.153
8	Income	0.109	0.319
9	Participation	0.342	0.040
10	Height	0.136	0.080
11	Weight	0.077	0.191
12	BMI	0.077	0.099
13	Postural inclination	0.034	-0.151
14	AHR _{res.}	0.174	0.102
15	AWHR	0.179	0.101
16	AHR _{rec.}	-0.172	0.124
17	SBP _{bef.}	-0.041	0.129
18	DBP _{bef.}	-0.140	-0.037
19	SBP _{aft.}	-0.174	0.091
20	DBP _{aft.}	-0.150	0.090
21	Moisture	-0.166	-0.414*
22	Time	-0.126	-0.154

** Significant at 1% level

* Significant at 5% level

TM- Traditional Method

UDMS- University Developed Maize Sheller

AHR_{res.}- Average resting heart rate

AWHR- Average working heart rate

AHR_{rec.}- Average recovery heart rate

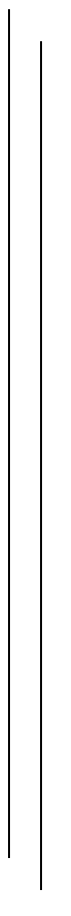
Table no. 4.22 show that coefficient of co-relation between shelling efficiency of traditional maize shelling and University developed maize sheller with selected independent variables. Shelling efficiency was taken as dependent variables, which correlated with 22 independent variables.

The analysis results indicated that in the traditional method, the independent variable was found to be non-significant with the shelling efficiency. In case of University developed maize sheller, the independent variable like Age (-0.405*) and moisture (-0.414*) was found to be negatively significant at 5 per cent level of probability. Which emphasize that efficiency will be increased with reduction in moisture of the maize cobs, since moisture has been found negatively significant at 5 % level of probability.





CHAPTER - V



SUMMARY AND CONCLUSION



SUMMARY AND CONCLUSION

Women farmers have been an important workforce in agriculture. They are the backbone of agriculture workforce. As per World Bank's 2014 report, the Indian female population comprised of 48.16 per cent of total population of our country. Women workforce in agriculture and allied sectors is 98 million, which is 37 per cent of total wage workers (Census, 2011). The farm women perform almost each and every agriculture activities right from land preparation, sowing, harvesting and storage of agriculture produce. In addition, now-a-days most of the women perform the dual activities. So far as involvement of women in agricultural activities is concerned, lots of rural women especially the farm women are performing agriculture activities, which involve less mechanized works. In rural areas about 60-70 per cent of agriculture operations is not work efficient and leads to cause drudgery. Ergonomics has a vital role in increasing the work efficiency with change in human behavior, abilities limitations and other characteristics to the design of tools, machines, tasks, jobs and environments for productive, safe, comfortable and effective human use (Saunders and McCormick, 1992). It contributes to design and evaluation of tasks, job, products, environments and systems in order to make them compatible with the needs, abilities and limitations of the people. Ergonomically designed items make the work more comfortable and workers more efficient.

Maize is the third most important cereal crop in India which accounts for 9 per cent of total food grain production in the country. Bihar is one of the largest maize growing state and this crop is grown primarily as a subsistence crop to meet food needs for a long time till recently. It is third largest maize producing state contributing around 10 per cent to national production. Around 0.65 million hectare is presently under maize cultivation, which is about 7 per cent of Gross Cropped Area (GCA) in the state and over 13 lakh farmers are engaged in maize cultivation. The maize crop is grown in all the seasons, i.e Kharif, Rabi and Summer. After harvesting, maize grain is harvested when it reaches its physiological maturity and contain 25-30 per cent moisture (Anonymous, 2001.). Normally cobs are plucked and therefore standing maize stalk is harvested. After plucking the maize cob is dehusked-manually and then dried in sunshine to reduce moisture content to 15-21 per cent (d.b) for further shelling whereas in some part, harvested cob (un-dehusked) is dried in sunshine and

then dehusking is done by hand prior to its shelling. Dehusking of cob is mainly performed by farm women in our state. The traditional practice followed by the farmers for taking out maize grain from cob (after dehusking) is either by beating the dehusked cobs with sticks or with finger or sickle etc. It is also observed that except beating with stick, removal of grain from rest method (finger sickle) is done by farm women. This operation is mostly performed by the traditional method and it is mostly done by women at their household. These farm activities are not only drudgeries but it also consumes time. During performing it is observed that usually women perform their activities unnatural body posture due to which their physical workload increases and they faces many types of muscular-skeletal problem as a results the efficiency of women to work decreases to a greater extent. Various studies on women in agriculture pointed out the fact that women are generally employed in the operations which are either not mechanized or least mechanized and involve a lot of drudgery. Thus, this operation is highly labour intensive with full of drudgery in addition to huge losses in quality and quantity of the agriculture produce.

However, few manual maize Sheller have been developed by the few Institutes; viz- CIAE, Bhopal and PAU, Ludhiana, Punjab in India. But which are not easily available in the market. On the other hand, farmers face the problems in manual maize shelling especially the breakage of the corn. Due to which women farmers are still using traditional methods to remove grains from the maize cobs and particularly in their unnatural body posture which affects the efficiency of farm women. However, Central workshop, Dr.RPCAUI, Pusa has designed a women friendly manual maize sheller and the concept of maize sheller was given by the Hon'ble Vice Chancellor. Dr Rajendra Prasad Central Agricultural University, Pusa. This machine needs to be ergonomically evaluated for its wide popularization in the state. Besides, the nature and extent of participation of farm women in agriculture activities are also affected by a host of factors, which include regional variations in nature of work, socio-economic status of the farm families and also the variation in agro-climatic condition. Moreover, there is dearth of information in maize shelling activity performed by women in our state. So keeping into consideration of these rational in mind this study has been planned with the following **objectives**:

- ❖ To study the socio-personal profile and physiological status of farm women performing maize Shelling.
- ❖ To assess the ergonomic analysis of maize shelling performed by the farm women.
- ❖ To compare efficiency of the existing University developed maize sheller over traditional method of maize shelling.

The study was conducted in Samastipur District of Bihar State. There are 38 Districts in the State and 20 Blocks in Samastipur, Out of which Pusa and Kalyanpur Block selected were purposively for carry out study. Two by villages will be purposively selected from each Block i.e Dhobgama and Malinager from Pusa and Kalyanpur Block respectively for convenience in data collection. From each village 30 (thirty) respondent was randomly selected. Thus, total number of sample size was comprised of 60 (sixty) respondents. All the 60 respondents involved in maize shelling activity was selected. Further out of 60 women respondents, 30 women respondents were taken as controlled group i.e 15 respondents from both the selected village. The anthropometrical data (height and weight) of all the 60 farm women was taken. Experiment was conducted on control group respondents (30) in three replications with respect to maize shelling activities. In both methods, 5 kg of maize cobs were given to each respondent per replications. Time was observed with the stop watch. The independent variables selected for the study were age, family type, family size, family education status, caste, occupation, income, social participation, height, weight, bmi, posture inclination, heart rate, blood pressure, cob dimension, moisture content of cob, weight. of grain, average number of cobs per kg, time and specification of machine. Efficiency, physiological cost of work and output capacity were taken as dependent variable. Relationship between the independent and dependent variables were calculated with the help of coefficient of correlation.

Salient Finding of the Study:

The major findings of the present study are summarized under major heads given below:

Social- Personal Profile of the Respondents

- The overall data related to the caste indicated that a majority of respondents (40 %) belong to age group of 21-30 years. Under control group an equal number of respondents i.e 33.30 per cent were in each three category of age. Whereas in general group the maximum number of respondents (46.6 %) were in age group of 21-30 years.
- The overall data indicated that a majority of respondents (68.3 %) were belonged to nuclear family. Under control group majority of respondents (70 %) had their nuclear family. In case of general group majority of respondents (66.7%) were from nuclear family.
- The analysis of overall data pertaining to the family size highlighted that a majority of respondents (58.3 %) had large family size. In case of control group (63.3 %) respondents were having their large family size. Whereas in general group majority of women (53.3 %) were having large family size.
- The overall data focused that 33.3 per cent of respondents were illiterate. In case of control group maximum of respondents were found to be illiterate (36.7 %). Whereas in general group maximum of respondents were illiterate 30 per cent.
- The data pertaining to the family education status of women showed that a majority of respondents having medium family education status (46.6 %). In case of control group fifty per cent of respondents had medium family education status. So as far as general group is concerned a majority of respondents were having their medium education level (43.3%).
- The overall data related to the caste indicated that a majority of respondents (36.6%) were belonged to EBC Category. In case of control group, it was reported that majority of respondents (43.3%) were belonged to EBC Category. But in case of general group maximum respondents (36.6%) were belonged to OBC Category.
- It was evident from the data that the (61.6%) of respondents in both general and control group were involving in farming activity followed by (21.6%) were engaged in labour work. In case of control group majority of respondents (63.3%) were engaged in farming. While in general group (60 %) respondents were practicing farming.

- The data on family income showed that majority of respondents belonged to high income group (36.6 %). In control group maximum of respondents group (40 %) high income group. While in general group (33.3%) respondents were in high income group.
- The overall data indicated that a majority of respondents (66.6%) of respondents were member in self-help group at present time. In control group, it was observed that maximum number of respondents (63.3%) were member in self-help group at present time. While in general group (70 %) of respondents were the member participating in present time.

Anthropometrical Dimension of Farm Women

- The overall data showed that the majority of respondents (46.6 %) had their height ranging from the 155-165 cm. In the case of control group, the majority of respondents (43.3 %) had their height ranging from the 145-155 cm. In general group, the maximum number of respondents (60 %) had their height ranging from the 155-165 cm.
- The data showed that the maximum respondents (51.6 %) had their body weight under the range of 40 to 50 kg. In control group maximum respondents (56.6 %) had body weight 40 to 50 kg. While in general group (46.6 %) respondents weight was 40 to 50 kg.
- The data pertaining to Body mass index of the respondents shows that the majority of respondents (66.6 %) were in normal category (20.5-25). In control group the majority of respondents (73.3 %) were in normal category (20.5-25). While in general group the sixty per cent of respondents were in normal category (20.5-25).
- The overall data regarding body type of the selected farm women revealed that the majority of the farm women had mesomorph (48.3 %) body type. In case of control group sixty per cent of the farm women belonged to the mesomorph body type. While in general group the majority of the farm women belonged to the ectomorph (43.3 %) body type category.

Ergonomic Evaluation of Farm Women Performing Maize Shelling

- In traditional method, the average energy expenditure (6.07 KJ m^{-1}) were found higher than the Univ. developed maize sheller i.e. 6.04 KJ m^{-1} respectively.
- Total cardiac costs of work (172.51) and physiological costs of work (9.76) were found to be the highest in traditional method. The percentage reduction in total cardiac cost of work came to be 56.15 per cent and 78.27 per cent reduction seen women's in physiological costs of work, while performing maize shelling with traditional method and University developed maize sheller. Total cardiac cost of work (13.82**) and physiological cost of work (-8.25**) was noted to be significant at 1% level of probability.

Postural Changes of Farm Women

- On an average postural change (26.13) was occurred due to standing and bending posture of women while performing maize shelling activity. Sitting posture of women while performing maize shelling activity was the mean value came to be 1.33.

Postural Inclination Analysis of Respondents While Performing Maize Shelling Activities

- In case of traditional method farm women adopted sitting posture during performing maize shelling, which fall under the high risk category on the basis of REBA score i.e 8. While in case of University developed maize sheller activity perform by the farm women adopted standing posture during work, which were undergone medium level of risk category on the basis of REBA score i.e 7.

Grip Strength of Farm Women in Maize Shelling

- Percentage change in University developed maize sheller over traditional method reduction in left hand grip strength was observed to be lower i.e 1.14 in University developed maize sheller as compared to traditional method. But the percentage change in University developed maize sheller over traditional method reduction in right hand grip strength was observed to be lower i.e 2.85 in University developed maize sheller as compared to traditional method.

Musculoskeletal Disorders Faced by Farm Women in Maize Shelling

- All women expressed pain in the leg, wrist, finger, upper back and lower back in traditional method. Majority 40- 46.7 per cent of farm women expressed pain in their wrist, upper back and lower back performed the maize shelling activity in University developed maize sheller.
- It was observed that in traditional method major musculoskeletal problems in maize shelling activity as reported by majority of selected farm women expressed that they had severe pain in wrist (80%), finger (73.3%), shoulder (56.6%), leg (53.3%) and upper back (53.3%). It was observed that major musculoskeletal problems in maize shelling activity were noted as moderate pain in their lower back (36.6%), wrist (36.6%) and upper back (30 %), upper arm (20%), leg (16.6%) and shoulder (13.3%) in improved method as reported by the selected farm women.

Extent of Exhaustion Expressed by Farm Women in Maize Shelling

- The mean score of feeling exhausted by traditional method in maize activity was found higher (4.23) than the mean score of feeling exhausted by improved method (1.53). 63.82 per cent of reduction in mean score of feeling of exhaustion was noted in maize shelling activity done with the University developed maize sheller compared to traditional method.

Difficulty Perception in Maize Shelling Performing by Farm Women

- The results revealed that, in traditional method, the mean score of difficulty perception in maize shelling performed by the respondents was (3.46) which was more compared to the mean score of difficulty perception (1.86) in improved method. Further, It was found that the perception of farm women's difficulties reduced by 46.24 per cent in case of University developed maize sheller compared to traditional method.

Opinion of Farm Women in Maize Shelling Activities

- Out of thirty respondents maximum respondents (66.7 %) had medium level of opinion they find them self at equal level of easiness and difficulty and their score ranging (41.9 - 47.5) in traditional method.

- Out of thirty respondents maximum respondents (73.3 %) had medium level of opinion that is they find moderate to use machine and their score ranging (45.4 – 51.1) in University developed maize sheller.

Time Management Practices of the Farm Women

- Data showed that out of the total sample maximum respondents (38.3 %) worked for agriculture activities for 1-3 hours. Under the control group maximum respondents (43.3 %) were working for 1-2 hours. In the general group maximum respondents (36.7 %) were working for 7-9 hours.
- Data indicated that maximum respondents (35 %) devoted 2-4 hours for the maize shelling activity. Maximum respondents in the control group (36.7 %) participating for maize shelling activity. In case of maize shelling activity maximum respondents (36.7 %) of the general group were worked for 2-4 hours.
- Data showed that out of the total sample maximum respondents (51.6 %) practiced in maize shelling since last 10-15 years. Maximum respondents in the control group (53.3 %) involving maize shelling for 10-15 years. For general group maximum 50 per cent respondents practiced the selected maize shelling for 10-15 years.
- The analysis of data highlighted that 58.33 per cent of respondents spent 4-6 hours per day for their household works. In the case of control group, the majority of respondents (53.3 %) were spending 4-6 hours per day in their household work. While 63.3 per cent respondents in general group were spending 4-6 hours in household works.
- On overall basis a large number of respondents (81.6 %) devoted 1-3 hours for leisure time per day in different group. In the control group 93.3 per cent of the maximum respondents in the control group were spending 1-3 hours' time for leisure. While in the general group 70 per cent of women were spending 1-3 hours for leisure period.
- A majority of respondents (83.3 %) spent 7-9 hours per day for sleeping. In the case of control group, a large number of respondents (80 %) spent 7-9 hours a day for sleeping. In the case of a general group, majority of respondents (86.7 %) spent 7-9 hours per day for sleeping.

- The data indicated that the majority of respondents (53.3 %) utilized 4-6 hours for other work i.e animal rearing, entertainments, personal care. In the case of a control group, the majority of respondents (53.3%) gave 1-3 hours for other works. In general group, the majority of respondents (60 %) spent 4-6 hours for performing other work.

Physical Characteristics of Maize During Shelling Activity

- The overall average length of cobs was noted as 17.59 cm and the circumference of cobs was 4.70 cm. The average weight of cobs was calculated to be 191.2 gm, the weight of 1000 grains was came to be 302. gm and the moisture content of maize cobs was 16.12 db.

Average Traditional and Machine Shelling Operation Value

- Higher output capacity of machine value was noted 70.20 (kg / h) as compared to the traditional method 16.97 (kg / h). The output capacity of the traditional method was found to be very low.
- The average loss of visual damage was found in traditional method was 0.63 per cent and machine value came to be 1.36 per cent. Unthreshed grain percentage of the traditional method was 0.02 percent and machine value was calculated to be 0.10 per cent respectively.
- Average time taken for removing grain from five kg maize cobs was noted as 17.68 minutes in case of traditional methods and by use of University developed Maize Sheller it came to be 4.28 minutes only.
- The overall shelling efficiency of the traditional method of maize shelling (86.15 %) was found to be slightly less than the shelling efficiency of the machine value was calculated as quite high i.e 87.73 per cent.

The Co-efficient of Correlation Between Output Capacity, Physiological cost of work and Shelling Efficiency of Farm Women with the Selected Independent Variables.

- The analysis of results related to output capacity (dependent variable) revealed that in the age group of 21-30 years the independent variables such as Family type (0.700*) was found to be significant at 5% level of probability. Whereas, time (0.996**) came to be significant at 1% level of probability. In

University developed Maize Sheller result shows that the independent variables such as family size (0.693*) and height (0.650*) was found to be significant at 5 % level of probability. Further, after systolic blood pressure (-0.665*) came to be negatively significant at 5 per cent level of probability. Whereas, the before systolic blood pressure (-0.768**), before diastolic blood pressure (-0.775**) and after diastolic blood pressure (-0.769**) came to be negatively significant at 1 per cent level of probability. Whereas time (0.901**) came to be significant at 1 per cent level of probability.

- The analysis of under the age group of 31-40 years results. The independent variables such as family type (0.644*) was found to be significant at 5 per cent level of probability and income (-0.644*) was found to be negatively significant at 5 per cent level of probability. While the time (0.988**) was noted to be significant at 1 per cent level of probability. In the University developed maize sheller independent variable like family size (0.659*) was found to be significant at 5% level of probability. Further, the time (0.988**) was found to be significant at 1% level of probability.
- Under age group of 41-50 years aged farm women, it was revealed that the independent variables such as time (0.995**) was found to be significant at 1% level of probability, while in University developed maize sheller the independent variable weight (0.634*) was found to be significant at 5% level of probability. Whereas time (0.987**) was found to be significant at 1% level of probability.
- The analysis of results related to physiological cost of work (dependent variable) revealed that family size (0.670*) and height (0.684*) was found to be significant at 5% level of probability. Under the age group of 21-30 years respondents. While in the traditional method of maize shelling the posture inclination (-0.750*) was found to be negatively significant at 5% level of probability. While in the case of University developed Maize Sheller result shows that the independent variables like height (0.851**) was found to be significant at 1% level of probability.
- Under age group of 31-40 years farm women, it was revealed that the independent variables such as occupation (0.637*) was found to be significant at 5% level of probability. While in the traditional method of maize shelling

- the posture inclination (-0.765**) was found to be negatively significant at 1% level of probability. While in the case of University developed Maize Sheller the independent variable like social participation (0.686*) was found to be significant at 5% level of probability. Further, the family type (0.855**) was found to be significant at 1% level of probability.
- The analysis of results highlighted that in the case of respondents age group 41-50 years, the independent variables such as occupation (0.664*) and income (0.730*) was found to be significant at 5% level of probability. While in UDMS the independent variable like age (0.666*) and Working heart rate (0.645*) was found to be negatively significant at 5% level of probability. The other parameters of the respondents i.e weight (0.793**) and recovery heart rate (0.778**) was found to be significant at 1% level of probability.
 - The analysis of results related to shelling efficiency (dependent variable) of machine revealed that under 21-30 years age group farm women the independent variables such as age (0.699*) was calculated to be significant at 5% level of probability. Posture inclination (-0.699**) and moisture (-0.694*) was found to be negatively significant at 1% level of probability. While in University developed maize sheller results focused that the independent variable such as moisture (-0.667*) came to be significant at 5% level of probability.
 - The analysis of results pertaining to 31-40 years age group respondents revealed that the independent variables was found to be non-significant with the shelling efficiency. In case of UDMS the independent variable as moisture (-0.671*) was found to be negatively significant at 5% level of probability. Further, analysis of the results pertaining to other age group respondents i.e 31-40 years age revealed that the independent variables such as family size (0.664*) was found to be significant at 5% level of probability. In case of University developed maize sheller all the independent variables were found to be non-significant with the shelling efficiency.
 - Further, the analysis of results highlighted that farm women in the case of age group 41-50 years, the independent variables were found to be non-significant with the shelling efficiency in both the method.

- The analysis of results related to output capacity (dependent variable) indicated that in the traditional method, the independent variables such as respondents education (-0.368*) was found to be negatively significant at 5 per cent level of probability. While time (0.995*) was calculated to be significant at 1 per cent level of probability. In case of University developed maize sheller, the independent variable like family size (0.377*) was found to be significant at 5 per cent level of probability. Further, the respondent's education (0.493**) and height (0.561**) was also noted to be significant at 1 per cent level of probability. Besides the time (0.968**) was also found to be significant at 1% level of probability.
- The analysis of results related to physiological cost of work (dependent variable) of the farm women revealed that the results highlighted that average working HR (0.442*) and average recovery HR (0.419*) was found to be significant at 5per cent level of probability in the traditional method. While occupation (0.536**) was found to be significant at 1 per cent level of probability. In case of University developed maize sheller, the independent variable like family type (0.368*) and income (0.431*) was noted to be significant at 5 per cent level of probability.
- The analysis of results related to shelling efficiency (dependent variable) of the farm women revealed that in the traditional method all the independent variable were found to be non-significant with the shelling efficiency. In case of University developed maize sheller, the independent variable like Age (-0.405*) and moisture (-0.414*) was found to be negatively significant at 5 per cent level of probability.

CONCLUSIONS:

Based on the result of the present study, following conclusion was drawn.

Manual shelling of maize is a time-consuming and tedious operation. The heart rate responses showed that the activity is light. Though the activity is light, women feel it as a maximum drudgery prone activity because of its monotony in performance, continuous sitting and performing it for a longer period of time. Hence University developed maize sheller has been proved as the best women friendly maize

shelling machine as it save energy, time and shelling has found quite high in comparison with traditional method of maize shelling.

This will lead to perform more work with lesser time and women can become an efficient maize shelling persons, which will make a women a self-reliant and self-confident. In nut shell, it can be said that women can earn money with adoption of maize shelling machine.

Implication of the Findings:

- I. It will be helpful for policy decision maker.
- II. It will be considered as a reference material.

SUGGESTION:

- There is need to make improvement in the design of maize inlet for performing maize shelling in sitting position, which will increase the efficiency of this machine. Since the maize shelling activities is accomplishes in a standing position which required much more time for repetitive bending for taking each maize cobs feeding through this existing University developed maize sheller.
- Front line demonstration of the machine may be carried out in different KVKs of central agricultural university, RPCAU, Pusa.
- Dissemination of knowledge regarding maize shelling activities with University developed maize sheller should be given in farmers fair organized in different parts of state.
- Dissemination of technology through presentation of research paper in conference, seminar and symposium organized in different parts of our country.





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APPENDIX



APPENDIX-I(a)

Interview Schedule for Data Collection

Sample No.:-

I. Demographic Profile –

District :

Block :

Village :

CorrespondenceAddress :

Contact :

II. Socio-personal & economic profile :

1. Age

a) 20-30 Years

b) 31-40 Years

c) 41-50 Years

2. Family Type

a) Nuclear

b) Joint

3. Family Size

a) Small(1-3)

b) Middle (1-5)

c) Large (>5)

4. Education of Respondent

Illiterate	Can read write	Primary	Middle	High school	Intermediate	Graduation	Above

5. Family education status:

S.No.	Relationship with family	Age	Illiterate	Can read write	Primary	Middle	High school	Intermediate	Graduation	Above

6. Respondents occupation

- a) No work
- b) Labour
- c) Business
- d) Farming
- e) Govt. service
- f) Any other

7. Income (Monthly)

- a) Up to Rs. 5,000
- b) Rs. 5,000-10,000
- c) Rs. 10,000-15,000
- d) More than Rs. 15,000

8. Social Participation

- a) No participation
- b) Member in past
- c) Member in present
- d) Member in past & present

9. Time management practices of the respondents

S.No.	Activities	Duration (Time in Minute)
		Duration per day
1.	Household Work	
2.	Agricultural Work	
3.	Leisure	
4.	Sleeping	
5.	Any other work	

10. How much time you devote for agricultural Works

- a) 1-2 hrs
- b) 3-5hrs
- c) 5-7 hrs
- d) Above 7 hrs

11. Do you practice Maize shelling activity- Yes/No

12. If yes, how much time you devote for maize shelling activity

- a) 0-2 hrs
- b) 2-4 hrs
- c) 4-6 hrs
- d) 6-8 hrs

13. Since how many years you are involved in work of maize shelling

- a) 1-4 years
- b) 5-10 years
- c) 10-15 years

APPENDIX-I(b)

Ergonomic Assessment of Maize Shelling by Women using traditional method and University developed maize sheller

Sample No:

Date: R₁:

Season: Kharif/Rabi

R₂:

R₃:

I. Anthropometric Dimension of the Respondents:

1. Name of respondent :

2. Age :

3. Height :

4. Weight :

5. Physiological dimension of Women involved in maize Shelling

Particulars	Resting heart rate	working heart rate	Recovery period of Heart rate (10 min.)	Time required for activity	Work Output (Kg)
Traditional methods					
Heart rate of Farm Women	R ₁				
	R ₂				
	R ₃				
Average Heart rate					
Univ. developed Maize sheller					
Heart rate of Farm Women	R ₁				
	R ₂				
	R ₃				
Average Heart rate					

6. Blood Pressure of Women involved in maize Shelling

Particulars	Before Maize Shelling	After maize Shelling
Traditional methods		
Blood Pressure of Farm Women	R ₁	
	R ₂	
	R ₃	
Average Blood Pressure		
Univ. developed Maize sheller		
Blood Pressure of Farm Women	R ₁	
	R ₂	
	R ₃	
Average Blood Pressure		

7. Posture inclination:

S.No.	Body parts	Maize shelling						Joint movement		
		Traditional method			Univ. developed Maize sheller					
		R ₁	R ₂	R ₃	R ₁	R ₂	R ₃	R ₁	R ₂	R ₃
1.	Trunk									
2.	Neck									
3.	Legs									
4.	Upper arms									
5.	Lower arms									
6.	Wrists									

8. Frequency of Postural Change

Postural used	Sitting	Standing	Bending
Frequency, R ₁			
Frequency, R ₂			
Frequency, R ₃			

9. Grip strength of Women for maize shelling

Activity	Muscular grip strength (Kgs)					
	During Rest		After Work		% Change in grip Strength	
	Left Hand	Right Hand	Left Hand	Right Hand	Left Hand	Right Hand
I Replication						
II Replication						
III Replication						
Average						

10. Musculoskeletal Disorders faced during maize shelling

S. No.	Upper Extremities	Maize Shelling Method			
		Traditional Method		Univ. developed Maize sheller	
		Yes	No	Yes	No
1.	Neck				
2.	Trunk				
3.	Legs				
4.	Upper Arms				
5.	Lower Arms				
6.	Wrists				
7.	Shoulder				
8.	Finger				
9.	Upper Back				
10.	Lower Back				

11. Musculoskeletal problems of farm women performing maize shelling

S. No.	Upper Extremities	Maize Shelling Method									
		Traditional Method					Univ. developed Maize sheller				
		1	2	3	4	5	1	2	3	4	5
1.	Neck										
2.	Trunk										
3.	Legs										
4.	Upper Arms										
5.	Lower Arms										
6.	Wrists										
7.	Shoulder										
8.	Finger										
9.	Upper Back										
10.	Lower Back										

Intensity of pain

5- Very Severe 4- Severe 3- Moderate 2- Light 1-Very Light

12. Feeling of exhaustion while performing maize shelling activity

Name of the activity	Very Exhausted (5)	Exhausted (4)	Moderately Exhausted (3)	Mildly Exhausted (2)	Comfortable (1)
Traditional Method					
Univ. developed Maize sheller					

13. Opinion of respondents regarding difficulty level faced by the women

Name of the activity	Very Difficult (5)	Difficult (4)	Moderately Difficult (3)	Easy (2)	Very Easy (1)
Traditional Method					
Univ. developed Maize sheller					

14. Opinion of women performing Traditional maize shelling activity

S. No.	Statements	SA	A	U	D	SD
1.	Do not feel uncomfortable while traditional maize shelling.					
2.	Feel backache while working in sitting position.					
3.	Working of drudgery prone activities is not tiring.					
4.	There is no damage of any body part while traditional maize shelling.					
5.	Heartbeat & breathing rate remain normal during maize shelling activities.					
6.	Get injured while working during maize shelling.					
7.	No feeling of pain in the hand and fingers during removal of maize grain from maize cob.					
8.	Eyes get red and irritated during maize shelling.					
9.	Get nose irritation, sneezing and feel suffocated when dust enters in nose or respiratory tract.					
10.	Lack of rest in between work does not deteriorate work output.					
11.	Thumb fingers become red and feel cramps while working with manual maize selling.					
12.	Pain in fist of hand.					
13.	Feel pain and cramps in legs while working in manual maize shelling.					
14.	Feel Backache during manual maize shelling.					
15.	Feel pain in neck.					
16.	Feeling of pain in shoulder.					

SD-Strongly disagree

D-Disagree

U-Undecided

A-Agree

SA-Strongly agree

15. Opinion of women performing Univ. developed Maize shelling activity

S. No.	Statements	SA	A	U	D	SD
1.	Do not feel uncomfortable while handling/working with machine.					
2.	Feel backache while working in bending position.					
3.	Sitting position is comfortable for working.					
4.	Working of drudgery prone activities is not tiring.					
5.	There is no damage for loss of any body part while working with machine.					
6.	Heartbeat and breathing rate remain normal during maize shelling activities.					
7.	Get injured while working during maize shelling.					
8.	Developed machine is comfortable for maize shelling.					
9.	Feel pain and cramps in legs while working with machine					
10.	Eyes get red and irritated during maize shelling.					
11.	Maize Shelling by machine is not a tough job.					
12.	Get nose irritation, sneezing and feel suffocated when dust enters in nose or respiratory tract.					
13.	Lack of rest in between work does not deteriorates work output.					
14.	Pain in fist of hand.					
15.	The use of machine does not put any stress on my back while working					
16.	Pain in shoulder.					

SD-Strongly disagree

D-Disagree

U-Undecided

A-Agree

SA-Strongly agree

APPENDIX-I(c)

Comparative Evaluation of Efficiency of University Developed Maize Sheller and Traditional Method of Maize Shelling

I. Crop Parameters:

1. Variety of maize crop:

2. Season of maize crop:

3. Maize Cob Dimension:

S.No.	Particulars	Value	
		Average	%(Percentage)
1.	Variety of crop		
2.	Length of maize cob (cm)		
3.	Circumference of maize cob (cm)		
4.	Weight of Maize cobs (gm)		
5.	Moisture content of maize cobs (db)		
6.	Weight of 1000 Grain (gm)		

4. Maize Shelling Machine Parameters:

S.No	Particulars	Traditional Method	Univ. Developed Maize Sheller
1.	Amount of maize shelling		
2.	Output (kg/hr)		
3.	Visual damage losses (% by Weight)		
4.	Un Threshed grain (% by Weight)		
5.	Time spent to shell 26 cobs (min)*		
6.	Shelling efficiency (%)		

Acceptability of Machine

S. No.	Statement	Opinion				
a)	Work stress	SA	A	N	DA	SDA
	• Need for postural change increases while handling Machine					
	• It restrains to maintain comfortable working posture					
	• It checks neck movement					
	• It adheres movement of shoulders and arms while working					
b)	Functionality					
	• It interrupts in work flow					
	• It affects your output					
	• It helps to improve efficiency					
c)	Convenience					
	• Handling Machine makes one conscious during work					
	• It protects from environmental hazards					
d)	Tool factor					
	• Size and shape of machine is comfortable to handle					
	• It is bulky in handling					
	• It is easy to move use body parts while working on machine					
e)	Field acceptability					
	• Hesitate to use for the fear of social acceptability					
	• Machine requires improvement/modification					
	• I am unable to use it without training					

SD-Strongly disagree

A- Agree

N- Neutral

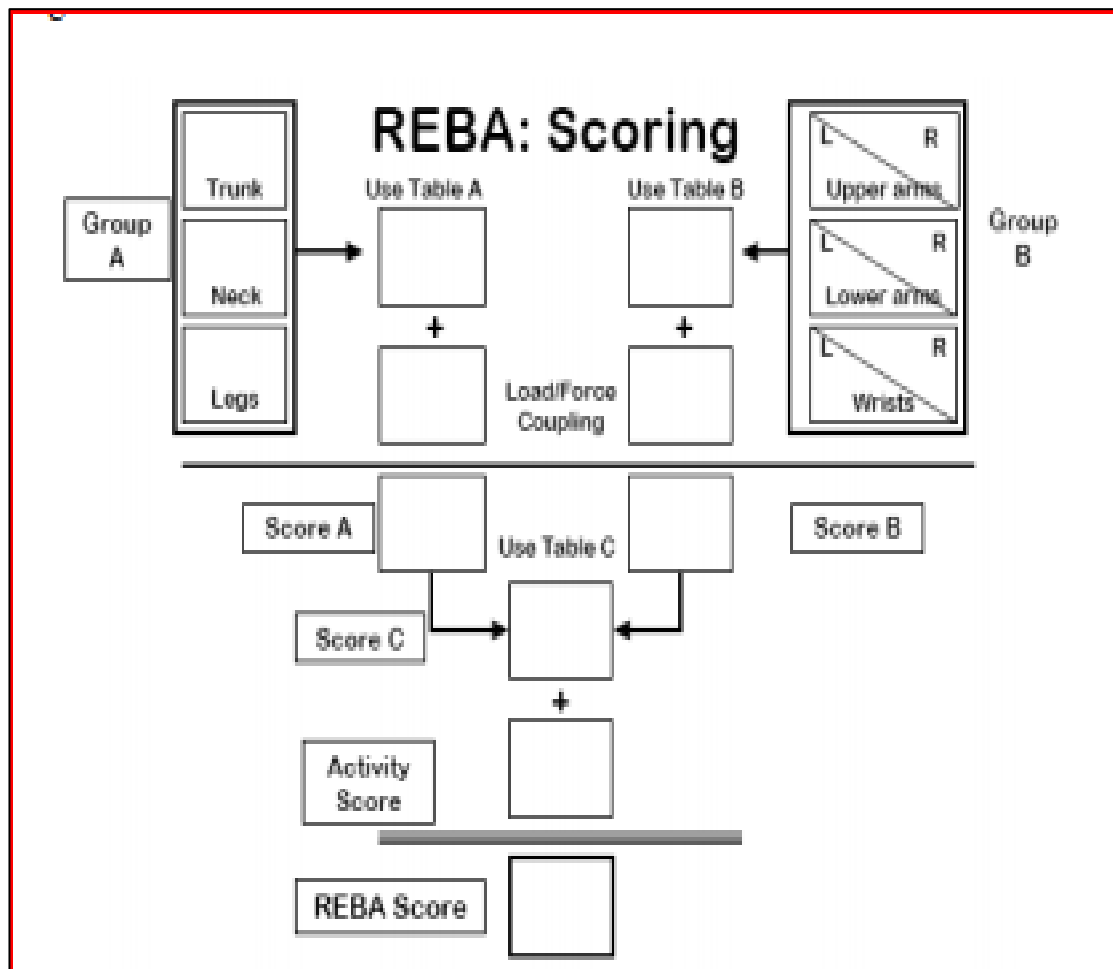
DA- Disagree

SDA- Strongly disagree



APPENDIX -II

REBA WORKSHEET



REBA Action Level

REBA Score	Risk Level	Action Level	Action (Including Further Assessment)
1	Negligible	0	None Necessary
2-3	Low	1	May be Necessary
4-7	Medium	2	Necessary
8-10	High	3	necessary
11-15	Very High	4	Necessary Soon

APPENDIX –III

Ergonomic Parameters of Respondents in Traditional Method

S.No.	Resting Heart Rate	Working Heart Rate	Recovery Heart Rate	Before		After	
				Systolic Blood Pressure	Diastolic Blood Pressure	Systolic Blood Pressure	Diastolic Blood Pressure
1	73.66	80.66	75	107	73.66	112.66	78.33
2	96.66	104.33	102	110.33	73.66	122	77.33
3	96.66	102.33	99.66	143	98	147.33	99.66
4	70	79.66	72.66	114.66	79.99	124.33	82
5	73.33	82	76	100.66	72.66	109.33	79.33
6	91.66	98	93.33	115.33	75	123.33	76
7	88.66	97	92	109	70	121.33	75
8	86.66	96	90.66	105.66	75	118.66	76
9	85.66	95.66	90	122	81.66	130.66	83.66
10	82	92.33	86.33	109	77	109.66	78
11	93.66	103	93.33	115.33	75	123.33	76
12	95	101.66	96.33	133.66	79.33	137.33	80.6
13	84	90.33	86.33	118.66	79.33	128	85
14	78	87.33	79.33	108.33	73.66	118.66	75.66
15	67	75.66	66.66	104	76.66	116.33	80.33
16	76.33	84.33	79	106.33	79.66	112.33	71.66
17	100	114	103.66	117.66	78.33	122.66	79
18	91	98.33	92	117.33	75	125	80
19	91.66	99.33	93.66	108.33	71.33	119.66	73.33
20	70	79.33	73.33	103.66	73	113.66	80.66
21	87.33	95.66	91	132.66	86.66	133.66	87.66
22	81.66	90	84.66	139.33	91	143.33	90
23	84	94.33	86.33	118.66	79.33	128	85
24	73.66	83.66	72.66	117	75.33	127	78.33
25	71.33	79.33	72.33	132.66	71	134	72
26	90.66	99.33	92	110.33	71.66	119.33	75.33
27	84	93.33	87.66	113	70.66	115.66	71.33
28	83.33	90.66	84.33	138	93	141.33	94
29	96	105.33	93.33	143	95	146	96.33
30	89.66	99.33	93.66	108.33	71.33	119.66	73.33
Mean	84.44	93.07	86.64	117.43	78.10	124.81	80.36

Ergonomic Parameters of Respondents in University Developed Maize Sheller

S.No.	Resting Heart Rate	Working Heart Rate	Recovery Heart Rate	Before		After	
				Systolic Blood Pressure	Diastolic Blood Pressure	Systolic Blood Pressure	Diastolic Blood Pressure
1	70	77.38	73.33	103.66	73	113.66	80.66
2	86.66	96.33	92	112.33	69.33	123.33	77
3	95	101.66	96.33	144	96.33	145.66	98
4	69.66	78	72.33	115.66	80	124.66	82
5	73.66	82.66	75.33	100	72	111.33	82.33
6	91	99.33	94	117.33	75.33	126	83
7	91	102.33	95	108.33	71.33	119.66	73.33
8	89.33	96.33	91	102	70	115.33	76
9	86.33	97	90.33	121.33	83	130	84.33
10	80.33	91.33	83.66	111.33	82.33	111	83
11	91	99.33	94	117.33	75.33	126	83
12	96.66	102.33	99.66	133.66	79.66	139	84
13	82	92	86.66	118.66	79.33	124.33	81.66
14	76	83	78.66	107.66	73	118	76
15	65	73.66	68.66	103	76.66	117	80.33
16	77.33	87.33	82	105.66	70.66	107.66	71.33
17	102.33	111	105.33	117.66	77.66	121	78.33
18	92	101.33	95.33	117.33	77.66	124	78.33
19	91	102	95	109	70	121.33	75
20	70.33	77.66	75	107	73.66	112.66	78.33
21	87.33	97.33	90	131.66	87.33	134	87
22	75.66	88.66	81.66	140.33	87.66	147.33	85
23	82	92	86.66	118.66	79.33	124.33	81.66
24	71.66	75	72	116.66	70.66	126.66	75.33
25	70.33	80	75	134	74.66	136.33	78
26	92.33	103	97.66	111.33	69.33	121	73.66
27	84	96.33	90.66	112.33	71	119	71
28	83.33	94.66	87	138.66	93	140	93.66
29	93.33	102.66	97	144.66	97.66	144.66	99
30	91	102	95	109	70	121.33	75
Mean	83.59	92.79	87.21	117.67	77.56	124.88	80.84

APPENDIX -IV

A. Calculation of Different Physical Characteristic of Maize cobs

Name of crop : Maize
Variety of crop : NK6607 Corn (Syngenta)

➤ Length of Maize cobs in cm

S.No.	Sample 1	Sample 2	Sample 3	Sample 4
1.	20.6	19.2	21	21
2.	19	19.4	17	19.3
3.	16	15.2	13.8	13.7
4.	17.6	21	18.3	14
5.	17	17	22	18.3
6.	20.6	19	17	21
7.	16.3	15.6	15	22.5
8.	15.8	20	14	20.5
9.	13	14	16	20
10	20	18.5	21	21
Mean	17.59	17.89	17.51	19.13
Overall	17.59 cm			

➤ Circumference of Maize cobs in cm

S.No.	Sample 1	Sample 2	Sample 3	Sample 4
1.	4.53	4.6	4.9	5.8
2.	4.5	4.5	5.2	4.6
3.	4.2	4.8	5.1	5.9
4.	4.8	5.5	4.9	5.8
5.	4.8	5.6	4.8	5.7
6.	5.1	5	5.1	5.6
7.	5	4.9	5	4.9
8.	4.6	5.1	4.5	4.8
9.	4.3	5.6	4.7	4.7
10	5.2	4.8	4.9	5
Mean	4.703	5.04	4.91	5.28
Overall	4.70 cm			

➤ **Weight of Maize cobs in gm**

S.No.	Sample 1	Sample 2	Sample 3	Sample 4
1.	236	190	221	230
2.	232	210	230	150
3.	169	200	215	175
4.	166	218	200	160
5.	167	180	185	180
6.	254	195	190	190
7.	180	170	198	195
8.	143	180	160	240
9.	110	200	190	220
10	255	195	189	195
Mean	191.2	193.8	197.8	193.5
Overall	191.2 gm			

➤ **Moisture content of Maize cobs in db**

S.No.	Sample 1	Sample 2	Sample 3	Sample 4
1.	15.3	16.2	15.8	17.2
Overall Mean	16.12 %			

➤ **Weight of 1000 grains in gm**

S.No.	Sample 1	Sample 2	Sample 3	Sample 4
1.	304	302	305	298
Overall Mean	302.2 gm			

B. Comparative Evaluation of Efficiency of University Developed Maize Sheller and Traditional Method of Maize Shelling

➤ **Output (kh/hr)**

S.No.	Age Groups	Traditional Method	University Developed Maize Sheller
1	21-30 yrs.	16.69	73.48
2	31-40 yrs	17.11	67.36
3	41-50 yrs	17.11	69.78
Mean		16.97 (kh/h)	70.20 (kh/h)

➤ **Visual Damage Losses (% by Weight)**

S.No.	Age Groups	Traditional Method	University Developed Maize Sheller
1	21-30 yrs.	0.62	1.36
2	31-40 yrs	0.64	1.34
3	41-50 yrs	0.63	1.39
Mean		0.63	1.36

➤ **Un-threshed grain (% by Weight)**

S.No.	Age Groups	Traditional Method	University Developed Maize Sheller
1	21-30 yrs.	.02	0.11
2	31-40 yrs	.03	0.09
3	41-50 yrs	.01	0.10
Mean		.02	0.10

➤ **Time utilized for maize shelling**

S.No.	Age Groups	Traditional Method	University Developed Maize Sheller
1	21-30 yrs.	17.97	4.08
2	31-40 yrs	17.53	4.45
3	41-50 yrs	17.53	4.30
Mean		17.68 min	4.28 min

➤ **Shelling Efficiency (%)**

S.No.	Age Groups	Traditional Method	University Developed Maize Sheller
1	21-30 yrs.	85.97	87.93
2	31-40 yrs	86.32	87.60
3	41-50 yrs	86.15	87.65
Mean		86.15	87.73