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# An Ergonomically Assessment of Manually Operated Maize Planter for Male Operators

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## ABSTRACT

A study was conducted at Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, (U.P), India on (2022–23) for ergonomic assessment of manually operated maize planter for male operators. Anthropometric data of age groups operators of (25–28, 29–32, 33–36, and 37–40 years) was determined. Heart rate, oxygen consumption rate, energy expenditure rate, and body part discomfort score of age groups were determined during working on maize planter. Anthropometric data of stature, arm length, standing eye height, knee height, and elbow height, and body mass index were determined for different age groups. Heart rate, oxygen consumption rate, energy expenditure rate, and body part discomfort score were increased when age groups increased at weight sample of seed (1.5 and 2.0 kg). Heart rate, oxygen consumption rate, energy expenditure rate, and body part discomfort score of 25–28 years age groups were found minimum and varied from 92–101 b min$^{-1}$, 0.36–0.37 l min$^{-1}$, 8–10.03 kJ min$^{-1}$, and 20.75–22.02 respectively on working. Heart rate, oxygen consumption rate, energy expenditure rate, and body part discomfort score of 37–40 years age groups were found maximum and varied from 140–143 b min$^{-1}$, 0.90–0.93 l min$^{-1}$, 19–20 kJ min$^{-1}$, and 51.23–53.87 respectively during working operators on maize planter at different weight samples.

**KEYWORDS:** BPDS, heart rate, energy expenditure, oxygen consumption

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***Data Availability Statement:*** Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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## 1. INTRODUCTION

Maize has been in the diet of India for centuries. It started as a subsistence crop and has gradually become a more important commercial crop. In industrialized countries, maize is largely used as livestock feed and as a raw material for industrial products. Maize is an important source of carbohydrates, protein, iron, vitamin B, and minerals (Singh et al., 2007). Africans consume maize as a starchy base in a wide variety of porridges, pastes, grits, and beer. Green maize (fresh on the cob) is eaten parched, baked, roasted, or boiled; playing an important role in filling the hunger gap after the dry season. In Africa, especially in sub-Saharan Africa countries, the use of hoes and cutlasses for crop cultivation is still prevalent due to abject poverty within the region. Agricultural operations are very labor-intensive in India (Fathallah, 2010). The occurrence of work-related ergonomics risk factors, in order to implement context specific and developing sustainable agricultural practices with better productivity and farmer's wellbeing (Patel et al., 2013). The word ERGONOMICS is derived from two GREEK words: ERGO means work and NOMOS means rules of laws (Pandve et at., 2017). Ergonomics is the scientific study of the relationship between man-machine and the working environment (Sahoo et al., 2017). Ergonomics is the scientific discipline mainly concerned with understanding the interaction of humans, and the scientific design profession that applies theory, principles, data, and methods to design and improve the work system involving machines or jobs with humans as an integral system (Karwowski, 2005). Ergonomic evaluation is a tool to evaluate the energy expenditure of work, their physiological cost, and suitability of the method for farm workers, and how long they can work continuously without getting fatigued (Sam, 2015). Every farm operation involves some drudgery which is considered physical and mental strain (Tiwari et al., 2021). To study the association between health and agriculture, the occupational hazards and health problems faced by agricultural women workers and the related policy provisions in India (Meenakshi et al., 2020). The need for ergonomics is the key in ascertaining the quotidian working performance of the respondents engaged in agricultural operations experiencing drudgery (Awasthi et al., 2020). The assessment of anthropometrical, physiological and body postural discomfort of the operators is the bottom-line in the ergonomic evaluation to compare the variations resulting during weeding operation (Mushobozi., 2010). The article concerns about human factors and ergonomics at workplace, how far a workplace and the equipment used there can best be designed for comfort, efficiency, safety, and productivity of human (Sirisha et al., 2019). It is imperative to consider safety during farm operation. Ergonomically designed implements allow ease and comfort to the farm workers during its manipulation and utilization (Awasthi et al., 2022). Selection of subject (workers) plays an important role whenever we are conducting an ergonomic study. The subjects are required to be medically fit and represent the real user population in the operation of the selected machinery. The selection is made based on gender, age, height, and weight. In India, generally male subjects are selected for conducting ergonomic studies on agricultural machinery (Siedel et al., 1980). Present anthropometric data of agricultural workers could be useful in design and development of manually operated weeders (Khogare et al., 2011) most of the agricultural operations are performed manually with the help of traditional tools (Khurpi. Anthropometry of male agricultural workers of north-eastern India and its use in design of agricultural tools and equipment (Dewangan et al., 2010). The aim of the study was the determination of anthropometric parameters of the operators and also to evaluate the physiological and postural discomfort parameters of different ages of operators at different weight samples of seed.

## 2. MATERIALS AND METHODS

The study regarding fabrication and ergonomic evaluation was governed at Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Naini, Prayagraj, (U.P), India during (2022–23). Manually operated maize planter was fabricated at the farm machinery workshop of the University.

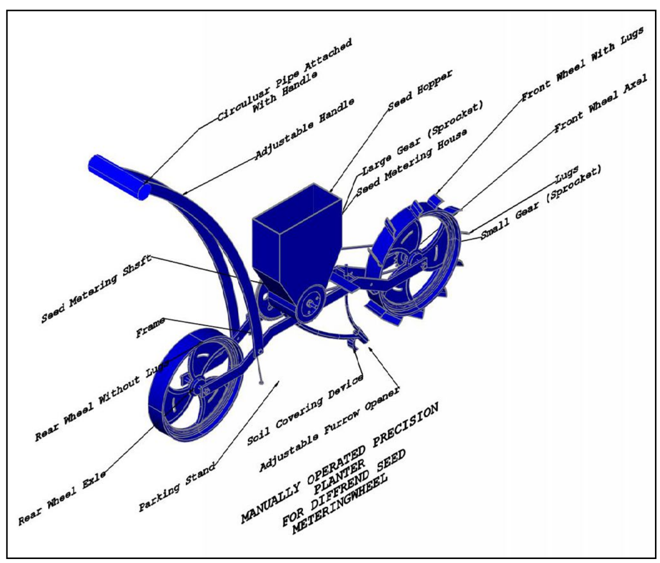



Figure 1: Manually operated maize planter

Sixteen male agricultural workers from SHUATS, Prayagraj in India had selected age subjects for study. The selection of subjects plays an important role whenever we are conducting an ergonomic study. In India, generally male subjects were selected for conducting ergonomic studies on agricultural machinery. For this study, different age subjects were selected from the available workforce of different ages varied from 25–40 years as given in table 1.

Table 1: Detail of selected different age subjects

| S.l. No. | Age group (years) | Height (cm) | Weight (kg) | BMI |
|---|---|---|---|---|
| 1. | 25–28 | 150 | 41 | 18.22 |
| 2. | 29–32 | 147 | 55 | 25.45 |
| 3. | 33–36 | 151 | 55 | 24.12 |
| 4. | 37– 40 | 146 | 56 | 26.27 |

• Integrated composite anthropometer-( for measuring multiple body dimensions)

• Measuring tape- (for various body dimensions)

• Pulse oximeter- (for measuring heartbeat)

• Weighing scale- (for measuring human body weight)

The first step is to find the weight and height of the subjects and find out the body mass index of each of them. Their health was determined by finding the body mass index is the formula given

BMI=Weight (kg)/Height $(m)^2$

*2.1. Determination of variables*

• Independent variable

a. Different age groups = 25–28, 29–32, 33–36 and 37– 40 years

b. Weight sample of seed=2.5, 3.5 and 5.0 kg (three replications R1, R2 and R3)

• Dependent variable

1. Heart rate (b/min)

2. Oxygen consumption (l $min^{-1}$)

3. Energy expenditure rate (kJ $min^{-1}$)

4. Body part discomfort score

*2.1.2. Oxygen consumption rate (l $min^{-1}$)*

The OCR of a subject on their measured heart rate was estimated based on a general equation as given by Singh et al. (2008).

OCR = 0.0114×HR–0.68

*2.1.3. Energy expenditure rate (kJ $min^{-1}$)*

The EER was computed by using the following equation given by Nag et al. (1980).

EER=20.86×OCR (kJ $min^{-1}$)

*2.1.4. Body part discomfort score*

To measure localized discomfort, Corlett and Bishop's (1976) technique was used. In this method, the body of the subject is divided into 27 regions. Each body region was numbered differently to avoid a subject marking on the body region only. The subject was asked to mention to all body parts with discomfort, staring with the most painful, the next painful in descending order till no further areas are referred. The number of different groups of body parts that are identified from extreme discomfort to no discomfort represented the number of intensity levels of pain experienced by the operators. If the maximum number of intensity levels of pain experienced for the experiment was five categories, the first category (body parts experiencing maximum pain) was given a rating of 5 and for the second category (body parts experiencing next maximum pain) rating was given as 4 and so on, for the fifth category (body parts experiencing least pain) rating was allotted as one. The number of categories of pain experienced by different subjects might vary. For example, if one subject has experienced 5 categories, the first category (body parts experiencing maximum) rating was allotted as 5 and for the second category (body parts experiencing next maximum pain) rating was allotted as 3.75 and so on for the fifth category (body parts experiencing least pain) rating was allotted as 1.25. The body part discomfort score of each subject was the rating multiplied by the number of body parts corresponding to each category. The total body part score for a subject was the sum of all individual scores of the body parts assigned by the subjects. The body part discomfort score of all the subjects was added and averaged to get the mean score. The same procedure was repeated for all the experiments the overall BPDS would be the average value of all the subjects (Figure 2).

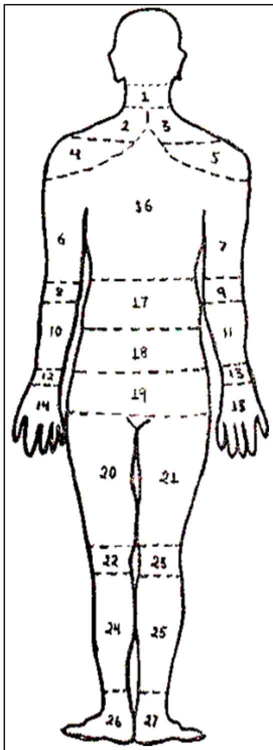
## 3. RESULTS AND DISCUSSION

*3.1. Anthropometric data of selected age subjects*

Anthropometric data of selected subjects were measured to the integrated composite anthropometer and measuring tape in complete resting condition. The measuring tape was used to all body dimensions record the anthropometric data. All the measurement using the tape was taken when the subjects were in a relaxed mode. Four subjects were selected from agricultural engineering farms of different age groups. It is presented in Table 2.

*3.2. Effect of workers' heart rates during operating a maize planter*

Heart rate of different age groups operators (25–40 years) varied from 92 to 143 bpm during operators of maize planter at different weight samples of seed (1.5 kg and 2.0 kg). The lowest heart rate was found at 92 bpm for the age groups (25–28 years) at the lowest level of weight sample and the highest heart rate was 143 bpm for the age groups (37–40



| | |
|---|---|
| 1: Neck | 15: Right palm |
| 2: Clavicle left | 16: Upper back |
| 3: Clavicle right | 17: Mid-back |
| 4: Left shoulder | 18: Lower back |
| 5: Right shoulder | 19: Buttocks |
| 6: Left arm | 20: Lift thigh |
| 7: Right-arm | 21: Right thigh |
| 8. Left elbow | 22: Left knee |
| 9: Right elbow | 23: Right knee |
| 10: Left forearm | 24: Left leg |
| 11: Right forearm | 25: Right leg |
| 12: Left wrist | 26: Left foot |
| 13: Right wrist | 27: Right foot |
| 14: Left palm | |

Figure 2: Region for evaluating body part discomfort score

Table 2: Anthropometric data of subjects under different age category for male operators

| S l. No. | Anthropo-metric data | Dimension (cm) | | | |
|---|---|---|---|---|---|
| | | 25–28 | 29–32 | 33–36 | 37–40 |
| 1. | Stature | 150±2.9 | 147±2.9 | 151±2.9 | 146±2.9 |
| 2. | Arm length | 64±2.9 | 63±2.9 | 64±2.9 | 62±2.9 |
| 3. | Arm span | 147±2.8 | 149±2.8 | 144±2.8 | 142±2.8 |
| 4. | Standing eye height | 139±2.6 | 136±2.6 | 139±2.6 | 132±2.6 |
| 5. | Sitting height | 111±1.9 | 113±1.9 | 110±1.9 | 111±1.9 |
| 6. | Sitting eye height | 100±2 | 101±2 | 104±2 | 99±2 |
| 7. | Popliteal height | 42±0.5 | 41±0.5 | 43±0.5 | 42±0.5 |
| 8. | Knee height | 48±1.9 | 46±1.9 | 47±1.9 | 45±1.9 |
| 9. | Pelvic height | 92±1.2 | 91±1.2 | 88±1.2 | 87±1.2 |
| 10. | Elbow height | 88±1.9 | 95±1.9 | 99±1.9 | 94±1.9 |
| 11. | Shoulder height | 111±1.5 | 113±1.5 | 117±1.5 | 110±1.5 |

Body part dimension±SD

years) at the higher level of weight sample. The main reason for increased heart rate with age groups was found to be the irregular design of maize planter. Tiwari et al. (2005) also reported that error in design consideration of machinery results in an increase in the workload and more discomfort among farm respondents for conducting any agricultural operation. Therefore, the results of the present findings shows same trend with Tiwari et al. (2005) (Table 3).

Table 3: Measured Heart rate of during working on maize planter

| Age (in year) | Heart rate for different age groups (beat min$^{-1}$) | |
|---|---|---|
| | 1.5 kg | 2.0 kg |
| 25–28 | 92 | 101 |
| 29–32 | 19 | 114 |
| 33–36 | 14 | 130 |
| 37–40 | 10 | 143 |

### *3.3. Effect of workers' oxygen consumption rates during maize planters are sowing*

The oxygen consumption rate of different age groups operators (25–40 years) varied from 0.36–0.93 l min$^{-1}$ during operators of maize planter at different weight samples of seed (1.5 kg and 2.0 kg). The lowest OCR was found at 0.36 l min$^{-1}$ for the age groups (25–28 years) at the lowest level of weight sample and highest OCR was .93 l min$^{-1}$ for the age groups (37–40 year) at the higher level of weight sample. The main reason for increased OCR with age groups found to be irregular design of maize planter. The physiological variation in the respondents increases with their age and significantly affects the performance of the farm respondents (Awasthi et al., 2022). The same results are yielded in the present findings. The results were also found by similar with to Singh et al. (2008) (Table 4).

Table 4: Measured oxygen consumption rate of the selected farm respondents

| Age (in year) | Oxygen consumption rate for different age groups (l min$^{-1}$) | |
|---|---|---|
| | 1.5 kg | 2.0 kg |
| 25–28 | 0.36 | 0.37 |
| 29–32 | 0.39 | 0.64 |
| 33–36 | 0.68 | 0.80 |
| 37–40 | 0.90 | 0.93 |

### *3.4. Effect of worker energy consumption when operating a maize planter*

Energy expenditure rate of different age groups operators (25–40 years) varied from 8 to20 kJ min$^{-1}$ during operators of maize planter at different weight sample of seed (1.5 kg and 2.0 kg). Lowest EER was found 8 k min$^{-1}$ for the age groups (25–28 year) at the lowest level of weight sample and highest EER was 20 kJ min$^{-1}$ for the age groups (37–40 year) at the higher level of weight sample. The main reason for increased EER with age groups found to be irregular design maize planter. The results were found by similar with to Nag et al. (1979) (Table 5).

Table 5: Measured energy expenditure rate of during working on maize planter

| Age (in year) | Energy expenditure rate for different age groups (kJ min$^{-1}$) | |
|---|---|---|
| | 1.5 kg | 2.0 kg |
| 25–28 | 8 | 10 |
| 29–32 | 10 | 14 |
| 33–36 | 14 | 17 |
| 37–40 | 19 | 20 |

*3.5. Effect of workers' in body pain scores while operating the maize planter*

Body part discomfort score of different age groups operators (25–40 years) varied from 20.75–53.87 during operators of maize planter at different weight sample of seed (1.5 kg and 2.0 kg). Lowest BPDS was found 20.75 for the age groups (25–28 year) at the lowest level of weight sample and highest BPDS was 53.87 for the age groups (37–40 year) at the higher level of weight sample. The main reason for increased BPDS with age groups found to be irregular design maize planter. The results were found by similar with to Kumar et al. (2002) (Table 6).

Table 6: Measured body part discomfort score of during working on maize planter

| Age (in year) | Energy expenditure rate for different age groups (kJ min$^{-1}$) | |
|---|---|---|
| | 1.5 kg | 2.0 kg |
| 25–28 | 20.75 | 22.02 |
| 29–32 | 29.04 | 30.86 |
| 33–36 | 39.91 | 42.22 |
| 37–40 | 51.23 | 53.87 |

## 4. CONCLUSION

Anthropometric data of age (year) subjects for male workers viz. stature, arm length, arm span, standing eye height, sitting eye height, popliteal height, knee height, pelvic height, elbow height and shoulder height were found out using ICA and measuring tape. With increasing age groups of subjects, heart rate, oxygen consumption, energy expenditure rate and body part discomfort score also increased when during working on maize planter at different weight sample of seed.

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