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Ergonomic Assessment of Traditional Weeding Tools Usage and their Management in Indian Agricultural Practices

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***Abstract*—Agriculture provides the basic means of livelihood for majority of Indian families. The farm workers use various types of tools, equipments and machinery for their day-today activities in the agricultural fields. Use of proper tools provides promising and encouraging results and hence it becomes utmost necessary to consider the human factors in the design of farm tools to enhance the operating efficiencies, working comforts and thereby improving the productivity of workers. Ergonomically designed equipments/products enhance the human operating efficiencies and comforts during its operation. In view of this, an effort has been made to assess the ergonomics involved in various postures of farm workers who are using traditional farm tools in their day today weeding activities. The main objective of the study is to ensure that the farmer's environment in traditional tools usage is providing a safe and healthful environment or not. Both male and female form workers who were using traditional tools for weeding operations & aged between 18-60 years were selected for the investigation and analysis. In the present work an assessment in virtual environment has been carried out using Rapid Upper Limb Assessment (RULA) tool using CATIA V5 ergonomic workbench. The assessment results reveals that several weeding posture positions are harmful and there is an urgent need to be addressed in detail about these postures as it is less investigated in the past literatures. The scores obtained during the assessment in each of the posture positions are discussed for necessary actions to be incorporated for safe and healthy working farming environment.**

Keywords— Agriculture, Weeding, Ergonomics, RULA, MSDs

1. INTRODUCTION

India is an agriculture based country where nearly 70% of the population in rural areas depends directly or indirectly on the income derived from agriculture [1]. Agriculture plays a vital role in Indian economy growth and provides employment to over 50 percent of its population. It also contributes about 15 per cent to the country's GDP. The agriculture and food processing sector plays an instrumental role in augmenting the growth of economy, as it is an important source of raw material for the industrial sector.

Intercultivation in agricultural practices will provide maximum opportunity for the crop to establish and grow strongly up to time of maturity. Tilling, cultivating and weeding are the major operations that are usually done in this stage of farming. Among these, weeding is one of the most significant farm operations in crop production and protection system [2]. Weed growth is a major problem for both dry and wet land crops causing a considerable lower crop yield. In northern Karnataka of south India most of the farmers use the traditional tools for the weeding process. The commonly used tools are sickle, hoe, manual/animal driven weeders, manual tiller [3], etc. It requires enormous amount of labour force to perform the work.

Four commonly used weeding methods in this region and their frequently practiced posture are discussed below.

1.1. Sickle (Khurpi): The Sickle (Khurpi) is a small and a very popular hand tool which is available in various shapes and sizes. It is commonly used as a hand tool in weeding process to remove weeds which are left within the crop rows. It consists of sharp, curved edged metallic blade with a wooden handle. The blade is made from medium to high carbon steel. The tool is operated by push-pull movement in squatting position.

Fig.1 Sickle and its usage

1.2. Hoe (Salaki): The Hoe (Salaki) is manually used hand tool used for digging and nursery bed preparation. It is also used for moving small amount of soil, piling soil around the base of plants creating narrow furrows and cutting small to medium plant roots. It consists of thin flat blade having an eye to which the handle is fitted. The eye is either welded to the blade or is an integral part of the blade. The tool is operated by frequently bending the waist to reach the ground.

Fig. 2 Hoe and its usage

1.3. Dry land manual weeder: Most of the farmers employ the mechanical method of weed control between the crop rows. Different types of cutting blades are used for manually operated weeders. These weeders are continuously pushed and the tool geometry of the cutting blades will help in weeding operation. It not only helps in weed control but also makes the soil surface loose, thus ensuring better aeration and water absorbing capacity.

Fig. 3 Dry land weeding

1.4 Animal driven weeder: Traditional bullock-drawn weeders are widely used for mechanical control of weeds in most of the weeding process. They are used to remove the weeds between the crop rows. Tool having straight or triangular shaped blades are widely used for weeding purpose. The farmers bend forward, move ahead along with the bullock and control the weeding process through hands.

Fig.4 Animal drawn weeding

INDIAN AGRICULTURAL ERGONOMICS: STATUS, CHALLENGES AND OPPORTUNITIES

Agriculture is generally recognized as the nation's most hazardous industry and displays high rates of musculoskeletal disorders (MSDs). It is also noticed that there is very little history of application of ergonomic approaches in agricultural equipment design [4]. Hence, there is a need for exploiting the available resources and technologies at appropriate and maximum level with changing agricultural scenario and global competition to enhance the productivity by introducing best ergonomical practices in agricultural region.

It is reported that the root reasons of many product complaints and failure can be related back to an ergonomic mismatch [5]. A good understanding of ergonomics and human interaction is a necessity for the product to become successful in the market. Ergonomics, human interaction and utilization of proper agricultural techniques lead to successful product in the present agricultural sector.

Even though majority of the rural population is actively involved in agriculture, nearly all the agricultural processes are still carried on by using manual methods especially by farmers having small holdings. It results in enormous wastage of human labour and hence low yields per capita labour force. It is also seen from the survey that there is a little amount of human aspects and ergonomics involved in the design of tools/implements and also in the farming environment in which they work. Ergonomically designed tools and working environment provides promising and encouraging results by enhancing the operating efficiency, working comforts and thereby improving the productivity of workers without compromising on their health and safety. Hence, there is an urgent need to consider these issues in improving the relationship between the farmers and their working environment.

2. MATERIALS AND METHODS

2.1 Selection of Subjects

The investigation is carried out in the various villages of north Karnataka region covering district of Dharwad, Belgaum and Gadag. The subjects selected were both male and female farm workers between the age group 18-60 years. Common crops cultivated at the time of investigations were Soyabean, paddy and white beans.

2.2 Ergonomic assessment of working posture

In the traditional agricultural tools design and in its working environment, the observation is made that the user-friendliness between the farmer-tool-environment is considered to a very smaller extent. This unsafe working condition would lead to Musculoskeletal disorders (MSDs) in the farmer community [6]. Common MSDs symptoms identified are hand/wrist pains, lower back pain, knee pain and neck pain due to wrist bending, body bending, and awkward posture while using the tools. In the study, the various postures of the agricultural farm workers who are following traditional weeding methods are assessed for ergonomics using Rapid Upper Limb Assessment (RULA) technique [7]. The different postures of the farmers in the weeding process were studied in detail for the assessment. Physical measurements in the field and still photographs are used to capture the various body postures in different weeding operations. The ergonomic assessment is made in virtual environment using CATIA V5 ergonomic workbench. The various postures of the weeding process are virtually built in the workbench and RULA tool is used to assess the working postures.

2.3 RULA technique

RULA (Rapid Upper Limb Assessment) is an accessing tool developed for the use in ergonomics investigations of workplaces where work-related upper limb disorders are observed [8]. This tool provides a quick assessment of the postures of the neck, trunk and upper limbs along with muscle function and the external loads experienced by the body in the working environment. The ranking of each posture is given by a score after complete posture analysis. Based on the final score of the assessment, four action levels will indicate the necessary actions to be taken to reduce the risks of injury due to physical loading on the worker. Various action levels of RULA investigations based on the final score is shown in Table 1.

Action level	*Final Score*	*Proposed Actions*
1	1-2	Posture is acceptable
2	3-4	further investigation is needed and changes may be needed
3	5-6	investigation and changes are required soon
4	7	investigation and changes are required immediately

Table1. Action level of RULA working posture

2.4 Anthropometric data for modelling body postures

Anthropometric data gives enormous amount of information to the designers and manufacturers for the development of ergonomically improved products and working environment. The body dimensions of human vary from region to region; hence region specific data is necessary in designing farm equipments [10, 11].

The mean anthropometric dimensions of Indian agricultural workers are considered and used to build the manikins. Important anthropometric data of the Indian farm workers are presented in the Table 2 [9].

Parameters	Male			Female		
	Mean	5th Percentile	95th Percentile	Mean	5th Percentile	95th Percentile
Anthropometric Data						
Weight, kg	54.7	40.4	68.9	46.3	33.5	59.1
Stature, cm	163.3	152.1	174.6	151.5	141.4	161.5
Eye height, cm	152.2	140.9	163.6	140.3	130.2	150.4
Acromial height, cm	136.2	125.6	146.8	126.1	116.8	135.3
Elbow height, cm	102.7	93.8	111.5	96.0	88.3	103.7
Iliocrystale height, cm	95.2	86.2	104.2	89.7	81.8	97.6
Metacarpal III height, cm	69.0	61.6	76.3	64.9	58.1	71.8
Grip diameter (inside), cm	4.8	3.9	5.7	4.5	3.5	5.5
Popliteal height sitting, cm	41.7	36.7	46.8	39.1	34.2	44.1
Buttock-popliteal length, cm	44.2	38.2	50.2	42.7	36.7	48.7
Hip breadth sitting, cm	31.1	25.8	36.4	30.2	24.9	35.5
Strength Data						
Hand grip Strength, N	360.0	209.0	511.0	224.0	93.0	355.0
Push strength, standing, N	224.0	132.0	316.0	143.0	79.0	208.0
Pull strength, Standing, N	218.0	142.0	294.0	158.0	95.0	223.0
Leg strength, sitting, N	429.0	261.0	598.0	319.0	172.0	466.0
Torque strength, Nm	55.0	24.0	85.0	41.0	24.0	58.0

Table2. Selected anthropometric and strength data of Indian agricultural workers

3. RESULTS AND DISCUSSION

3.1 Analysis of the working postures

Based on the different weeding methods and the postures involved in them, the assessment results are obtained. The different weeding postures are virtually built and the RULA method of assessment is carried out in CATIA Human Posture Analysis.

3.1.1 Sickle (Khurpi) using posture

Most of the farmers use sickle for removing the weed which are left in between the crop rows. The sickle is operated by push-pull movement in squatting position. In the squatting positions during the weeding operation, the observed body movements are- spine bending, neck bending, knee bending, bending and twisting of the wrist. The common MSDs symptoms identified are the knee pain, neck pain, lower back pain and wrist pain.

The detailed assessment of the posture is made and the final score obtained from the assessment using RULA method is **Score-7** for both right and left side of the body which indicates that the posture needs to be changed immediately as it results in work related MSDs. During the assessment of the sickle operation posture, it is assumed that the position is static. Figure (5) shows the virtual model of the sickle usage posture and its RULA assessment results.

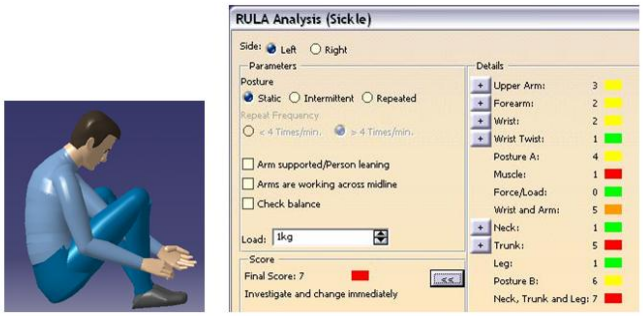

Fig. 5 Virtual Model of Sickle using position and RULA result of the posture

3.1.2 Hoe (Salaki) using posture

During the operation of weeding by using hoe, the body movements observed are- frequent bending of the waist to reach the ground, knee bending, neck bending and wrist twist/bending. In the field study it is observed that the hoeing operation is intermittent, where the farmer does the work for 10-12 minutes followed by 3-4 minutes rest. In the ergonomic assessment, the same intermittent operation is taking into account. The common MSDs recorded were- lower back pain, shoulder pain, neck pain and knee pain.

The detailed assessment of the posture is made and the final score obtained from the assessment using RULA is **Score-5** for both right and left side of the body which indicates that the posture needs further investigation and it is required to change the posture soon, as it results in work related MSDs in near future. Figure (6) shows the virtual model of the hoe usage posture and its RULA assessment results.

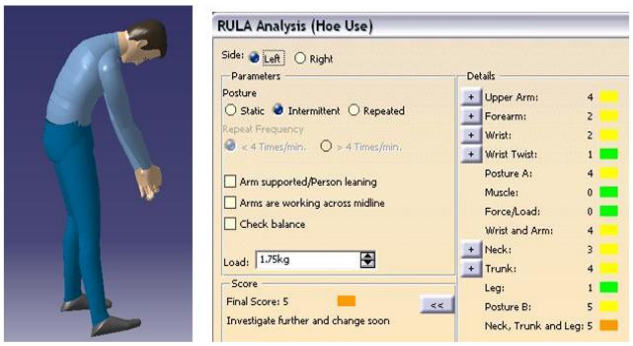

Fig. 6 Virtual Model of Hoe using position and RULA result of the posture

3.1.3 Dry land Manual weeding posture

In the dry land manual weeding, the farmers perform the weeding operation by pushing the weeder in between the crop rows. The blades of the weeder will remove the weeds effectively and makes the soil surface loose. Manual weeding is intermittent where in the farmer bend the spine in forward direction with arms holding weeder handle and moves forward to remove the weeds. The common MSDs recorded were- lower back pain, shoulder pain, and knee pain.

In the ergonomic assessment using RULA, the final score obtained considering the posture as intermittent is **Score-5** for both left and right side of the body. The result obtained is interpreted as further investigation and changes needed soon. The risk of injury in the process is present and hence there chance of having MSDs. Figure (7) shows the virtual model of the hoe usage posture and its RULA assessment results.

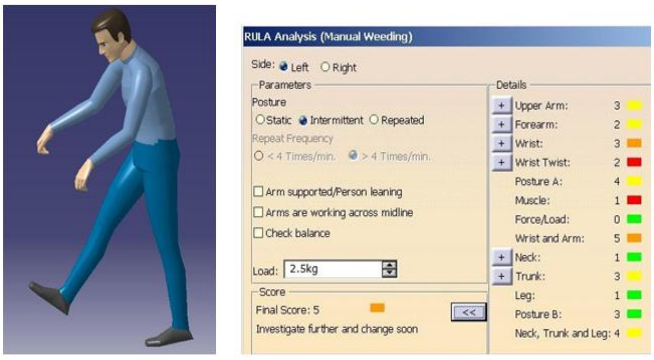

Fig. 7 Virtual Model of Manual dry land weeding position and RULA result of the posture

3.1.4 Animal driven weeding posture

Most of the weeding process in the region is done by using bullock driven weeders. The body postures observed during are-spine bend, spine twist, arm bend, knee bend and wrist twist/bend. Lower back pain, shoulder pain and knee pain are the common MSDs documented during the study.

The RULA ergonomic assessment made on the posture revealed the final **Score-4** for left side and **Score-5** for right side of the body indicating to investigate further and change the posture. Since all of the subjects were right handed, it is observed in the study that the right shoulder and hand is bent and twisted more than the left hand. Hence the two different score for the left and right side is obtained. Figure (8) shows the virtual model of the hoe usage posture and its RULA assessment results.

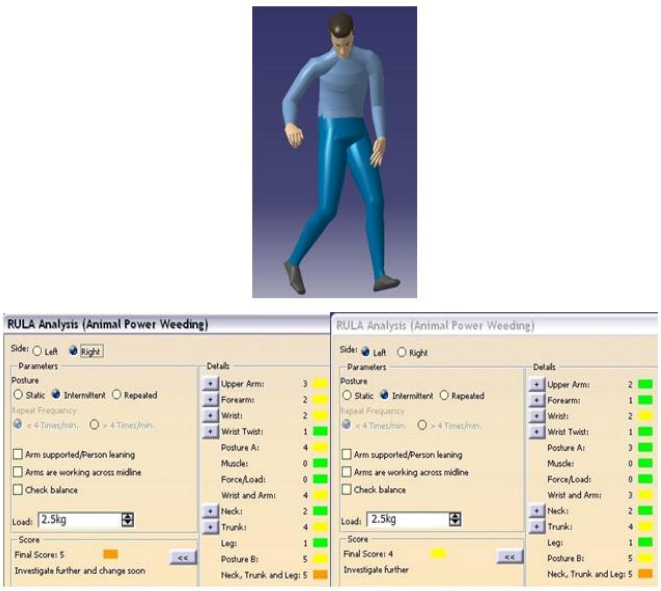

Fig. 8 Virtual Model of Animal weeding position and RULA result of the posture

3.2 Injury management and prevention

Good working postures and use of proper human factors in design of farm implements may prevent musculoskeletal injuries in the agricultural working environment. Intensive working over long durations without much halts in-between can increase the risk of developing MSDs.

Following actions are suggested in order to reduce the work related injuries in the agricultural weeding process when traditional tools are used.

- Prolonged squatting position during weeding operation would gradually and eventually result in musculoskeletal injuries on workers. An adjustable stool of proper height is recommended to use during the sickle weeding process. While sitting, rest the elbows-arms on chair or armrest with shoulders in relaxed position.
- Regular breaks/ halts are necessary after every 15-20 minutes of weeding process.
- Avoid sitting in the same position for more than 20 minutes.
- During dry-land and animal driven weeding process distribute body weight evenly on both hips.
- Handles of the tools should be covered with smooth materials either plastic or rubber to avoid tools slipping from hands while weeding.

4. CONCLUSIONS

From the study it is observed that the weeding process is tedious work done in agricultural fields. The agricultural workers work constantly in a bent posture and remain in awkward and stressful positions during the weeding process. These postures have resulted in pain in different parts of the body- specifically the lower back, neck, hand/wrist, knee and shoulders. The uncomfortable working posture not only results in the development of MSDs but also affects the quality and productivity of work. In the paper, the four main weeding practices in northern Karnataka region are analysed for their ergonomics in the working environment. It is seen from the RULA assessment that most of these postures are harmful and there is a possibility of developing MSDs if used continuously for longer durations. Farmers need to consider ergonomics during every farm related activities to improve the quality of farming process and hence enhancing the agricultural production. An exhaustive training and workshop regarding the work related injuries in agricultural process is necessary to bring the awareness in the rural environment. Farm workers should be educated about the harmfulness involved in the traditional agricultural practicing postures.

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