

ERGONOMICS: A HUMAN FACTOR APPROACH FOR THE DEVELOPMENT OF FARMERS IN AGRICULTURE

Abstract

Agriculture is mostly documented as the country's most dangerous industry, and with high rates of musculoskeletal and whole-body disorders that include several risk factors agricultural workplaces have very little history of using ergonomic methods. Agriculture considers ergonomics a very important subject because it is an interdisciplinary science that tends to align between work and workers to safeguard the health and safety of an individual farmer. It can help to determine which methods are in place to carry out agricultural work that will not only stabilize but will improve working conditions for workers with a few small convenient steps. However, more collaboration is needed among engineers, ergonomics experts, physicians, and manufacturers in terms of creating new ergonomic technologies and raising employee sanity about risk factors.

Keywords: Ergonomics, Agriculture sector, Problems of agricultural workers, biomechanics; musculoskeletal disorders; risk factors

Author

Vinay Kumar

Research Scholar in Farm Machinery and Power Engineering
Department of Farm Machinery and Power Engineering Punjab Agricultural University Ludhiana, India.
vinaykumarmangotra27@gmail.com

I. INTRODUCTION

The agricultural industry plays a strong role in meeting basic human needs by providing food in rural areas and creating large amounts of jobs. In India, more than 70 percent of the rural sector relies on agriculture as the main source of income (Kumar V and Dogra R, 2023). It provides raw materials and various types of employment opportunities for other industries. As a result, the safety and health of its employees are of great importance, given the key role that agriculture plays in the global economy. However, the occupation of the profession involves many harmful diseases and illnesses. Agriculture is considered one of the unsafe sectors in both developing as well as developed countries (Babu, 2016). It is seen as one of the most susceptible to the drudgery of the workers in the agricultural sector because of the lack of improvement in agricultural machinery (Mehta, 2012). Poor health conditions such as musculoskeletal syndromes are directly related to agricultural activity. (Singh and Arora 2017). Many farmers complained of back pain as a health problem at work in agriculture. Farmers have confronted many problems in agriculture due to lack of appropriate equipment and poor information about the working environment.

According to the International Labour Organization, there are about 160 million work-associated diseases annually worldwide which play an important role in terms of work health and the economy (Niu, 2010). The World Health Organization also stated that there are many factors that cause or exacerbate work-related shortcomings such as work requirements, social factors, job environment characteristics, and cultural factors. In this regard, ergonomics has played an important role in the health of workers. In addition, the major concern is related to the problem being faced by the majority of female staff (Parimalam *et al.* 2005). Otherwise, most of the work in agriculture occurs due to the requirements of physical muscles, uncomfortable postures, long-standing and kneeling, sewing, bending, and frequent muscle activity. Unquestionably these things will lead to exhaustion, illness, disease, and accidents. In addition, the lack of sufficient knowledge of agricultural health and safety workers leads to life-threatening situations.

Currently, mechanization in agriculture encompasses most agricultural processes as a way to reduce rigorous manual labour, improve task time and increase productivity (Kumar V and Bector V, 2022). But in many cases, the introduction of machinery does not eliminate worker's health problems such as full body vibration, dust during harvest, and engine fume exposure. Therefore, interest in the use of practical procedures in agricultural conditions is growing in order to help reduce work-related accidents, diseases, illnesses, and various other various problems related to the human body. Thus, among workers in the agricultural industry, ergonomics can play a problem-solving role and reduce musculoskeletal damage (Nunes, 2009).

Ergonomics is the process of determining the best match of comforts of types of equipment or machine with the worker in the working environment (Figure 1). It is an interdisciplinary science that strives to make job and worker-matching environments better to make them safe. The purpose of ergonomics is to test a person for his range, strength, speed, and endurance of movement, so as to design the working environment and equipment ergonomically as per the best well-being requirements of the workers so that workers can use them without difficulty and safely. (Dombekova, 2016). The effectiveness and efficiency of the worker can be increased through the implementation of convenient interventions in the

agricultural industries. With convenient assessment and appropriate measures, not only risk factors for workers are studied, but some practical ways of preventing uncomfortable situations are also included (Richardson *et al.* 2005).

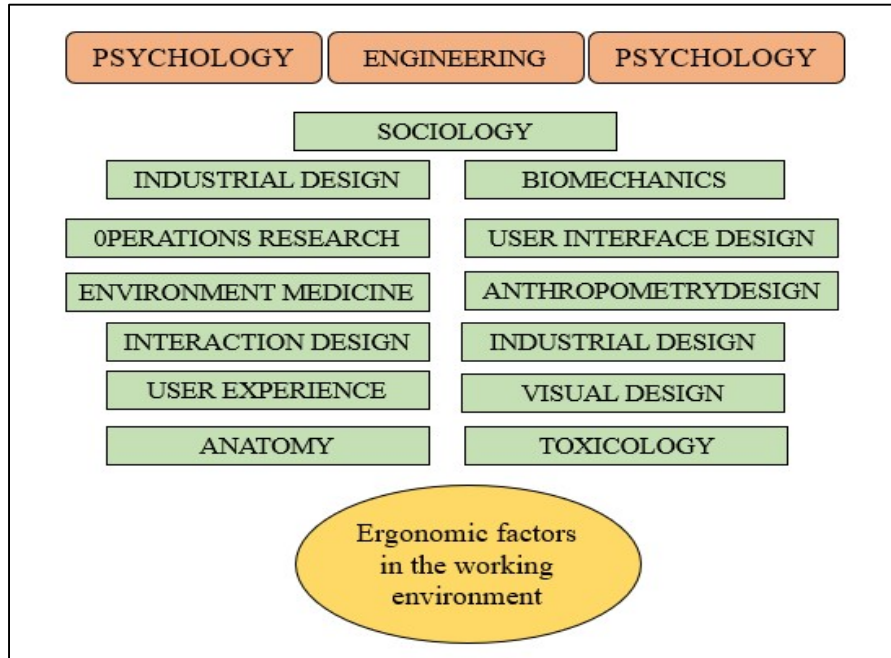


Figure 1: Worker and Ergonomic factors in the working environment

II. BRANCHES OF ERGONOMICS BASED ON DISCIPLINES

1. Physical Ergonomics: It applies to human anatomy that includes anthropometric, physiological parameters, and biomechanical properties of the worker that is related to physical movement. Among many problems associated with the working environment, the most important is the posture that workers adopt during physical working which causes problems related to physical fatigue, muscular, and skeletal load, and physical exertion. The principles of physical ergonomics are extensively used to design both user and industrial products to improve performance and prevent work-related shortcomings by reducing the mechanisms underlying severe and chronic mechanically induced musculoskeletal damages/disorders (Kumar V and Parihar NS, 2018). In a stable office environment, risk factors such as confined mechanical stress, strength, and posture result in injuries related to the working environment. The physical environment of work is more important (Figure 2), especially for people diagnosed with diseases or physiological syndromes such as arthritis. Today many products are designed consulting the standards of physical ergonomics and indorsed to treat chronic stress-related pain and avoid such disorders.

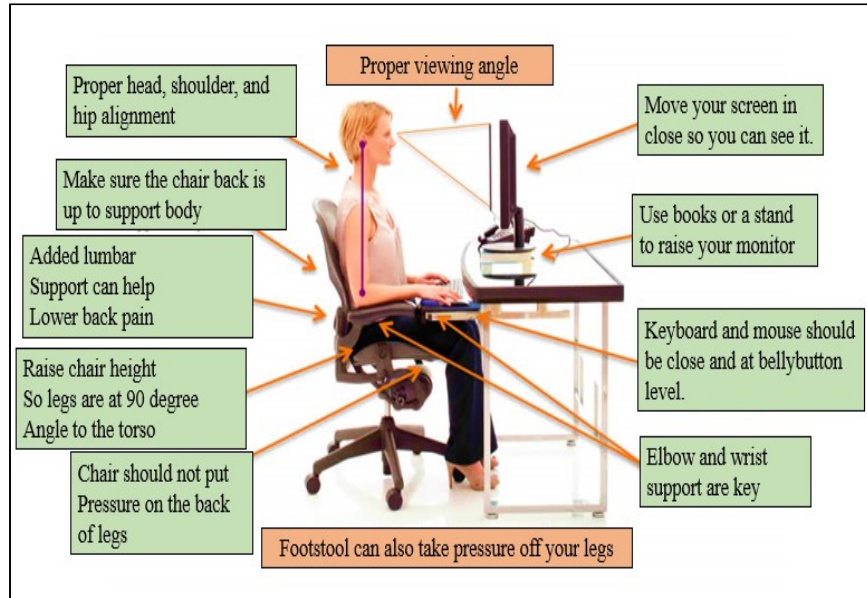


Figure 2: Sitting Posture in a Working Environment

2. Cognitive Ergonomics

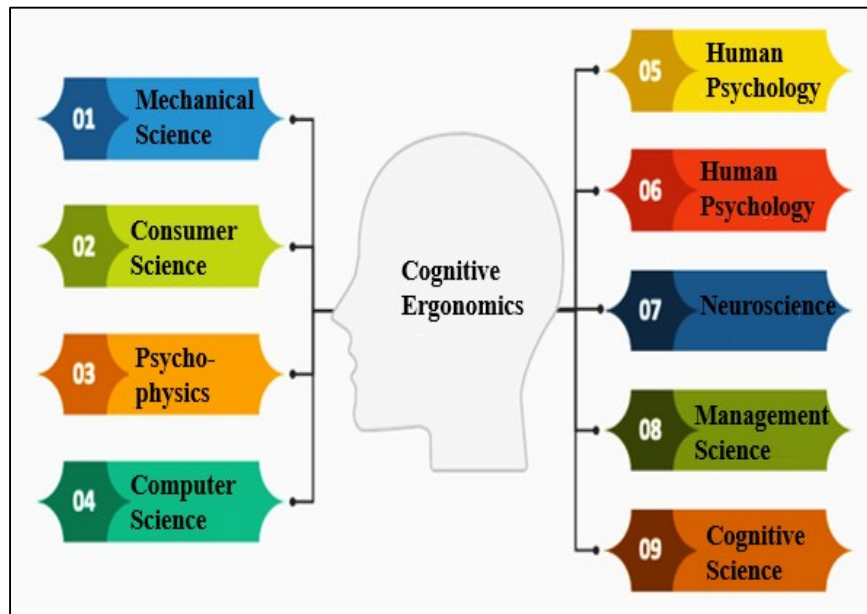


Figure 3: Cognitive abilities flow chart

It is a part of the ergonomics discipline that includes study research, evaluation, design changes, functions, products, environments, systems, and their interaction with humans and their cognitive capabilities (Figure 3). The International Societies of ergonomics association for the Work Environment quoted that it relates to mental

processes such as cognition, memory, thinking, and motor reaction because they affect how people interact and other elements of the system. It is the quality of the work environment that studies cognitive developments in the workplace that lay stress on understanding the situation and supporting consistent, efficient, and acceptable performance. This approach solves problems such as decision-making, ease of use of human and computer systems, formation of learning skills, cognitive characteristics of the psychological load, mental trauma, and mistakes at work.

- 3. Neuro Ergonomics:** It is defined as the study of the human mind related to the performance of the workers at work and daily routine work. It combines the theories, neuroscience, standard procedures of ergonomics, and human intervention factors to offer valuable information about brain activity and behaviour as found in natural environments. For example, tilt angle during phone usage can exert different levels of pressure on the discs and joints of the cervix which immediately affects spinal cord pulling and muscle strain (Figure 4). This can further lead to cognitive decline, poor concentration, brain tiredness, low energy levels, sleep problems, and lack of compassion. This is moderately a new development involving the use of deeper neurophysiological methods such as brain mimic methods. These progressive methodologies can be used to evaluate users' liking for human-computer interface options for specific to a specific design or version of manufactured products (Ayaz *et al.* 2013).

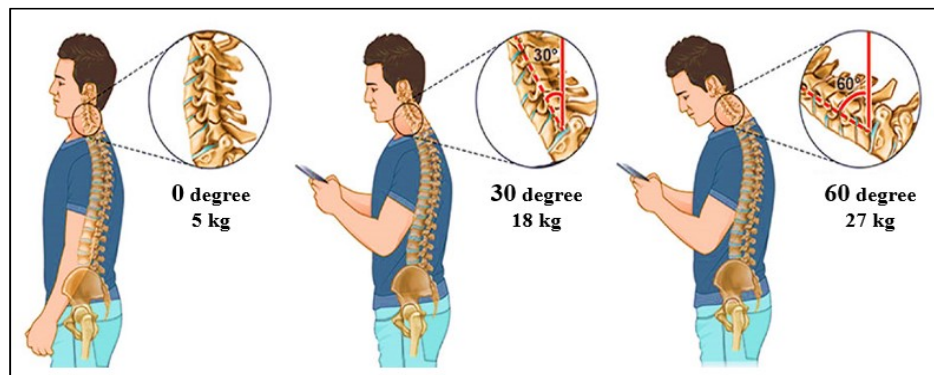


Figure 4: Posture and Neuro-Ergonomics

- 4. Organizational Ergonomics:** It involves the improvement of social and technical work arrangements, together with organizational measures, as well as their structures and policies. Therefore, ergonomic specialists are often involved in the social design and development of communication systems, interactive procedures within working groups, company schedules and shifts during working hours, and other interrelated issues. Ergonomics by definition is an interdisciplinary ambition (Singh, 2012a). Multidisciplinary scientists and experts are interested in designing various characteristics of social and technical systems. So, they can all be termed "ergonomics" in logic, with additional specifications based on individual emphasis, from the physical and neurophysiological aspects to the mental, social, and organizational features based on the attention as per the requirement.

III. APPLICATION OF ERGONOMICS IN THREE MAJOR AREAS

- 1. Design of Human-Machine Systems:** It is a system in which one or more workers are related to one or more devices, machines, and apparatus. For example, a worker doing drilling at work, or a person with a hammer will drive a nail into a carpentry, a post office, a fire protection system, or a pharmacy can be an efficient/productive system or a facility system (FAO, 2011). The ergonomics are practically applied to acclimate these systems in order to provide system operators with maximum work satisfaction and comfort as well as minimal physical and mental load.
- 2. Design of Consumer Goods and Facility Systems:** Ergonomics applies to the design of consumer goods, starting with the design of toothbrushes and other elements such as Kitchen appliances, crockery sets, tables, sofa sets, home accessories, shoes, etc. In the same way, protective equipment such as gloves, goggles, collision helmets, severe weather and spacesuits, firefighting, etc., must be designed economically and soundly (Singh, 2012b).
- 3. Design of Working Environment:** When designing a suitable work environment for the workers at working workplace, various factors related to the working environment such as the durability of body lighting, temperature, pollution, noise, and ventilation should be considered. This aspect must be taken into account at each stage, from the correct design, down to actual use or actual service (Singh, 2008). Its scope of application is unlimited and all factors involved in workplace design, public transportation, road systems, urban and rural planning, employees, communities, and the environment such as airports must be comfortably analysed on the basis of ergonomics. Users of convenient information for civilians or engineers such as electrical or mechanical, industrialist, or biomedical must make use of anthropology, psychology, and sociology studies as relevant sources of information.

IV. ERGONOMIC ASPECT OF AGRICULTURAL TOOLS AND IMPLEMENTS

In addition to performing the intended function of agricultural equipment, the points taken into account when designing agricultural equipment and the bending of equipment, not of the worker, to take into account the dynamism of people, to give workers a minimum muscle effort, taking into account 30 percent of the power of the 5th percentile worker (women). Taking into account the 95th percentile of the relevant anthropometric data of employees (users) for a place in an establishment with certain allowances, for push or pull types of agricultural equipment, the fifth percentage required for manual transportation, taking into account the weight of employees (users) does not exceed 30 percent or taking into account safety aspects, etc. Anthropometry (dimensions), aerobic muscle strength capacity, position, load capacity, safety issues, physiological of the working environment and other many factors are important on the basis of ergonomics in the design and development of agricultural instruments and manual equipment (Gite *et al.* 2009).

- 1. Anthropometry:** In most developing and underdeveloped countries, small holder farmers use hand-operated or animal-powered tools to carry out land-making and tilling tasks, which are usually developed by village craftsmen and due to a lack of their anthropological knowledge while building manual implements. Measurements of diverse

body sizes are required according to the needs of the specific designs of agricultural equipment. In different body sizes, differences in weight and physique of male and female employees are compared, since these two parameters provide most of the solutions to many problems. All women on farms in India weigh 21% less in the fifth percentile than male workers compared to male employees from anthropometry data of various states such as J&K, Mizoram MP, Tamil Nadu, Maharashtra, Punjab, Meghalaya, Odisha, Arunachal, Gujrat, and West Bengal. (Table 1).

The fifth percentile weight of West Bengal workers was the lowest amongst other states. It was also found that the fifth percentile values of the agricultural status of women are 8 percent lower compared to male employees (Gite *et al.* 2009). These data clearly indicate the ergonomic characteristics of agricultural employees including men and women. It is also proposed to carefully use anthropometric data according to the participation of agricultural employees in the process for which agricultural tools will be designed. Typically, percentile from 5 to 95 are taken for design to meet 90% of users. Data is taken for the 5th percentile where access is required, while the 95th percentile data is taken for space purposes.

Table 1: Anthropometric Data of Male and Female Workers in Indian

Dimension of Body	Men		Women		5 th percentile difference
	5 th	95 th	5 th	95 th	
Eye height (mm)	1409	1636	1302	1504	8.22
Maximum grip length (mm)	94	151	81	138	16.05
Vertical reach (mm)	1923	2237	1778	2063	8.16
Shoulder grip length (mm)	628	818	579	749	8.46
Weight (kg)	40.4	68.9	33.5	59.1	20.60
Stature (mm)	1521	1746	1414	1615	7.57
Span (mm)	1562	1832	1422	1680	9.85
Vertical grip reach (mm)	1829	2141	1689	1973	8.29
Grip inside diameter (mm)	39	57	35	55	11.43
Acromial height (mm)	1256	1468	1168	1353	7.53
Sitting height (mm)	744	916	702	847	5.98

- 2. Muscular Strength:** Most professional activities are carried out through worker intervention. In these cases, a person's ability to accomplish mechanical work is calculated based on his ability to use his/her muscle strength. For example, strong people may lift heavier weights than their weaker peers. Despite the increase in automation, the requirements for human strength for physical activity are still strong. The nature of several work tasks and job situations involves employing muscle strength. For example, when processing materials in limited spaces, transporting patients from their beds to other places or carrying out maintenance activities. Muscle strength is also necessary to use the implements and controls or to exert the necessary forces and mesh to protect the external load pressure without causing personal damage (Figure 5).

Lack of strength can cause an increased load on the joint system of Tendon muscular bones and thus cause injury. The relationship between lack of strength and wound is widely recognized for handling hand materials and work that requires the use of manual equipment. Thus, the knowledge of muscle strength or power is very important to develop such products for the prevention of musculoskeletal-related problems and injuries (Pavlich, 2016).



Figure 5: Lifting posture ergonomically to avoid muscular stress

- 3. Aerobic Capacity:** The maximum rate of oxygen consumption that determines a person's maximum physical working power is also called aerobic capacity. When performing any type of aerobic workout, the body uses oxygen to fuel the metabolism process (converting the food into useful energy), which provides energy to the body for any type of motion. For women, this rate is largely 75 percent of the value of men. According to the data available, this value for male and female employees in India is about 2.0 l/min and 1.5 l/min, respectively.

Some devices such as Samsung or Apple Watch may be used to estimate maximum VO₂ based on heart rate, age, mass, and gender during exercise. These instruments can only offer approximate evaluations and cannot provide accurate measurements. In order to accurately assess aerobic capacity, you will need to perform an indirect calorimeter test (Fig. 6). One needs to undergo an indirect thermometry test as an alternative test to get an accurate assessment of your aerobic abilities. Depending on where you live, it can be difficult to find this test. Check if there are proper labs, or hospitals that can offer these tests. Indirect calorimetry tests involve wearing a mask over the face to measure the breathing rate while doing intense exercise on a treadmill or lab bike and normally takes less than 10 minutes to accomplish this breathing test (Mani, 2014).



Figure 6: A View of Calorimeter Test

4. **Posture:** Good working condition requires minimal static muscle strength to improve performance and reduce discomfort in the body. Any process in the curve or curve of posture involves a scourge and is also reflected in terms of the distress experienced by employees. Therefore, it is necessary to avoid this situation as much as possible during working hours. It is also possible that a long-term sitting position is better than a standing position (Caffaro, 2018). Discomfort is the physical pain of the body caused by excessive muscle strain. While work is good within physiological limits in many situations, discomfort in the body may limit the length of work depending on the component of the static load involved, as is much agricultural activity.

5. **Load-Carrying Capabilities:** Shipping and transportation are the most important events in agriculture. The manual tools and other commodities like seeds, manure, lifting and transport of the harvested products and grains, etc., the burden that the worker must bear should not exceed 40 percent of the body weight of any individual. The loading mode should be such that one must avoid static loading of hands or arms (Fig. 7). But this restriction applies only to plains or mountainous terrain, and the restriction will depend less on slope or terrain.

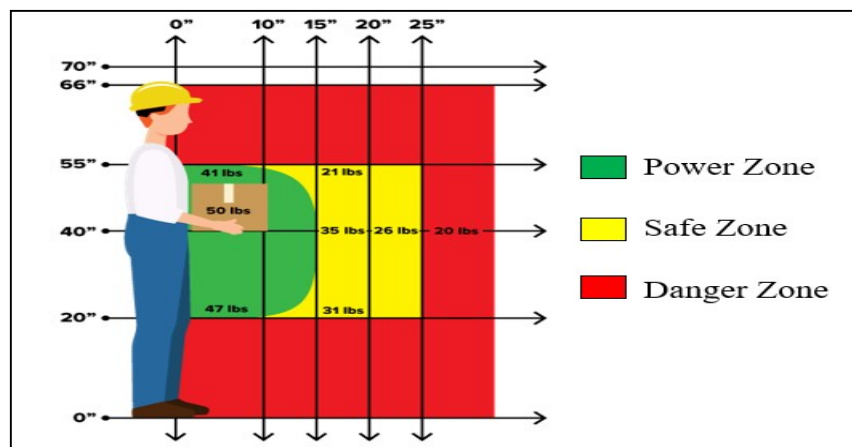


Figure 7: Recommended load Carrying Limit at Vertical and Horizontal Posture

V. WORK DONE ON ERGONOMICS IN INDIA AND ABROAD

Geographical Distribution of Research Studies Contribution to Ergonomics: The concern for ergonomics in agricultural machinery and processes seems to be of keen interest to developing as well as developed countries. Notably, no input from Africa was found, perhaps because most rural tasks there are still done manually, with fewer existing research institutions compared to developed countries. A considerable research study contribution was observed from Italy, New Zealand, Sweden, Serbia, India, Malaysia, the USA, and Canada. Greece, Poland, and Iran, whereas less contribution was observed from Brazil, Spain, the United Kingdom, Norway, Austria, Japan, Korea, and Thailand (Fig. 8). In total, the biggest source of the literature on ergonomic research surveys was Europe whose research institutes were more involved in ergonomics research. However, similar research studies on ergonomics in the design and development of agricultural machinery systems were carried out on a large scale in South Asia, Oceania, and North America (Benos *et al.* 2020).

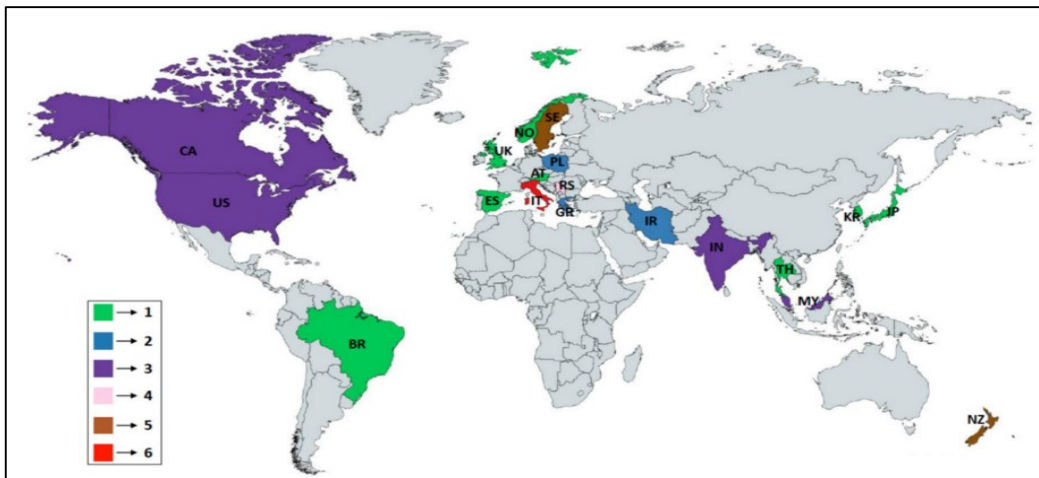


Figure 8: Geographical Contribution of Organizations in Ergonomics Studies

The geographical distribution covers a number of scientific disciplines, including musculoskeletal and whole-body disorders, work-related health risks and protection issues, industrial product design, ergonomics studies, and manual tool design. A number of research studies focus mainly on designing manual hand equipment and educational programs to improve the farming environment. The studies done in various countries percent-wise and on particular crops are shown in Fig. 9 and Fig. 10. Most studies are located in the United States, so there is a surging demand that studies should be conducted in developing countries and some Asian countries.

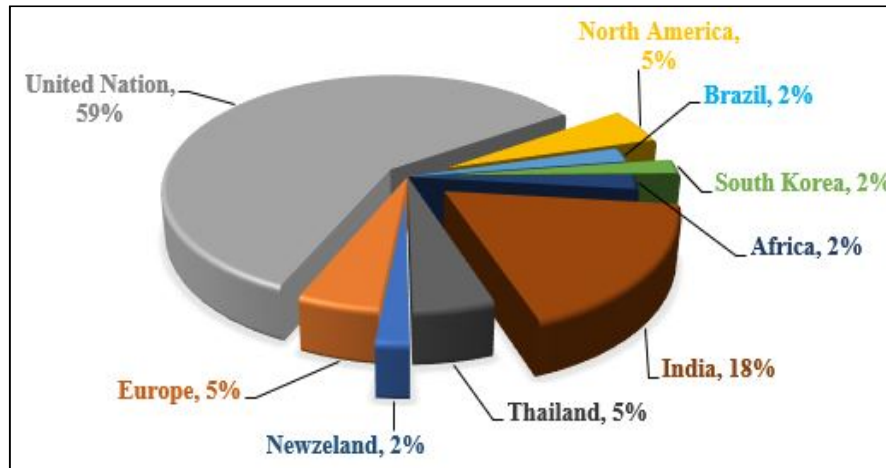


Figure 9: Countries-Wise Share of Studies Related to Ergonomics

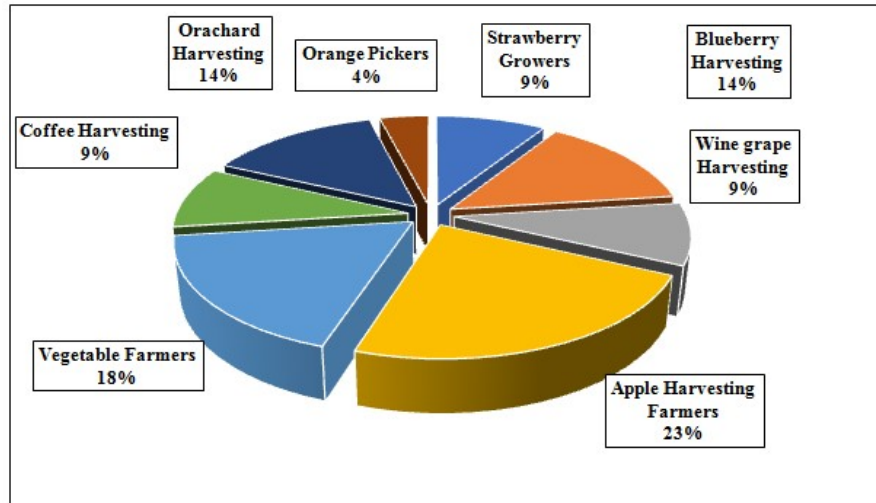


Figure 10: Crop-Wise Share of Studies Related to Ergonomics

VI. ERGONOMICS FUTURE NEEDS IN DEVELOPING COUNTRIES

The work environment and its applications strive to reconcile the work and work environment to promote individual well-being by improving productivity and work efficiency and improving the condition of the employee and user. In order to increase productivity in developing countries, the study of the working environment, research must be concentrated in the industrial segment. It is also observed that very little work is done in ergonomics, especially in agriculture where most of the work is done manually but it has great potential to improve and provide quality of life.

VII. CONCLUSION

Ergonomists can develop and offer solutions to agricultural challenges that are attractive in terms of economic concepts, particularly for low-income communities. In

addition, appropriate government agencies, large-scale agricultural companies and employers will be able to solve the favourable costs. Active participation and cooperation in the work environment is very important in this regard. In fact, some activities should be done simultaneously to develop a new practical method of ergonomics intervention and analysis of tasks through design. Convenient intervention allows workers to increase their productivity by reducing drudgery. Most importantly, the present researchers need to think to understand the issues related to the agricultural workers.

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