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# Ergonomic Assessment of Risk Factors among Farmworkers in Vegetable Production System

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**ABSTRACT**

Vegetable production activities are very high labor demanding, during various activities workers adopted different postures like bending, twisting, standing and sitting which are directly associated with drudgery and occupational health hazards. The purpose of combining ergonomics with farm workers who are engaged in the vegetable production system is to reduce drudgery and provide an appropriate working environment that enhances their working capacity as well as productivity. The present study was carried out in vegetable research center Pantnagar, Udham Singh Nagar, Uttarakhand to study activity profile and to assess work-related health hazards among farm workers by analyzing their work postures, during land preparation, nursery preparation, sowing, transplanting, weeding, irrigation, spreading of manure and harvesting of tomato, broccoli and garlic vegetable production. The total population sample of respondents (N=30) was selected for descriptive data on different activities from land preparation to harvesting vegetables. The descriptive data was collected with the help of an interview schedule and postural analysis methods such as REBA, RULA and OWAS. The RULA, REBA and OWAS scores were analyzed with the help of ERGO FELLOW software, whereas SPSS version 26.0 software was used for statistical analysis such as frequency, percentages, mean and multiple linear regression). The analysis of data revealed that farm workers suffered from various health hazards during the various activities of the tomato, broccoli and garlic vegetable production system. It was found that joint pain is a cause of concern in harvesting, transplanting, weeding and irrigation activity. It was also found that in multiple linear regression of work-related health hazards, the 'p' value is found to be highly significant for the age of the respondent, which indicates that the age of the respondents has a high impact on work-related health hazards in the vegetable production system in tomato, broccoli and garlic.

*Keywords* : RULA, REBA, OWAS, Musculoskeletal disorders, Vegetable production system

OUR country is blessed with diverse agro-climates with distinct seasons, making it possible to grow a wide array of vegetables. Agriculture plays a significant part in meeting people's basic requirements by supplying food and creating jobs on a huge scale in rural areas. In India, agriculture is the primary source of income for about half of the rural population (Kaur, 2015). Agriculture is considered the backbone of the Indian rural economy and is a family enterprise. It is an important engine of growth and poverty reduction. India's economic security is heavily dependent on agriculture (Satyavathi *et al.,* 2010). India, behind China, is the world's second-largest producer of vegetables, with 2.8 per cent of total cropped land dedicated to vegetables (Kumar *et al.,* 2011). Indian agriculture continues to remain the leading industry in the country contributing vastly to the socio-economic growth of India (Mun Ghosh and Ghosh, 2014). The term 'vegetable' is somewhat subjective and mainly defined through culinary and

cultural traditions. In addition, vegetables had a short duration, high yield, nutritional richness, economic viability, and potential to produce on-farm and off-farm employment, vegetables are important aspects of Indian agriculture and nutritional security. The growing demand for vegetables is considered to have a favorable economic effect on small holders who dominate the Indian agriculture scenario. Farm workers are exposed to various health hazards during performing agriculture tasks because most agricultural work is done outside; agricultural employees are reliant on weather variations to complete their responsibilities. This element not only degrades the efficiency of activities but also has an impact on their working conditions, which is more difficult and dangerous for them (*e.g.,* a rainstorm while harvesting, gusts of wind when pesticides are being applied, etc.). Agriculture is one of the most dangerous industries in both developing and developed nations. Pesticides and other agrochemicals provide serious occupational risks, including poisoning, death and in some cases, cancer and reproductive problems (Engberg, 1993 and Van & Konradsen, 2005). The farm workers perform almost every agricultural activity right from land preparation and sowing to the harvesting and storage of the agricultural produce (Hasalkar *et al.,* 2004). Total vegetable exports from India accounted for 5419 crores during 2018-19, sharing 2.25 per cent of total agricultural exports and 0.23 per cent of total national exports (Commission for Agriculture Cost and Price 2020). India accounts for nearly 16 per cent of the world's production of vegetables and the productivity of vegetables in India is 17.3 t/ha, which is less than the world's average productivity of 18.8 t/h (Indian Institute of Vegetable Research, 2020). During 2018-19, India exported 3.33 million tonnes of vegetable products worth 5679 crores (National Horticulture Board, 2019; Vasavada, 2021).

Moreover, farm workers are also involved in a variety of tasks in the vegetable production system, including land preparation, nursery preparation, sowing, transplanting, weeding, irrigation, manure spreading, and harvesting. Due to their low knowledge and competence, farm workers conduct these various duties in a traditional manner, which occupies the majority of their time and energy. The transplanting, weeding and harvesting operation was found to be more labor-intensive in the vegetable production system. It is largely done manually in India and most developing countries and incurs large investments in labor, time, and cost.

The primary purpose of an ergonomic solution is to improve employee health and well-being by eliminating risk factors in the workplace, which can be done by altering the activity or instruments utilized, or by altering the worker's physical position. Studies were carried out on the comparative performance of three crops tomato, broccoli, and garlic in vegetable production with the aim, to study the demographic and activity profile of farm workers engaged in a vegetable production system, postural analysis of farmworkers through subjective techniques, and to identify the work-related health hazards experienced by the farmworkers during different types of work activity.

## Methodology

The study was conducted in the vegetable research center, Pantnagar, Udham Singh Nagar, Uttarakhand. A descriptive research design was planned to achieve the objective. A total of 30 respondents from the above locale. An interview schedule was developed and tested assessment of the activity profile of farm workers engaged in vegetable cultivation (nature of involvement of farm workers in various activities of vegetable cultivation, adoption of posture during various activities of vegetable cultivation and level of discomfort faced by the female workers), identification of work-related health hazards experienced by the farm workers and work-related musculoskeletal discomfort.

The data were analyzed with the help of ERGO FELLOW software for the working posture of the respondents in various activities of vegetable production, whereas multiple linear regression at a 5 per cent level of significance with the help of SPSS (Statistical Package for Social Sciences) Version 26.0. The assessment was with the help of Ergo fellow software which analyzed the score of Rapid Entire

Body Assessment and Rapid Upper Limb Assessment. Researchers McAtamney and Corlett (1993) developed the RULA method as a tool to assess individual worker exposure to risk factors associated with work-related upper-limb disorders, such as postures adopted, repetitive motions and forces required. Hignett and McAtamney (1993) developed REBA as a way to analyze posture for the risk of work-related musculoskeletal illnesses (WRMSDs).

## Results and Discussion

### Assessment of Activity Profile of the Farm Workers Engaged in the Vegetable Production System

In the vegetable production system, farm workers play an important role in the entire vegetable growing process, from land preparation to harvesting. Farm workers are engaged in various activities such as land preparation, nursery preparation, seeding, transplanting, weeding, irrigation, spreading of manure and harvesting.

Table 1

Percentage distribution of respondents as per their years of involvement in the vegetable production system (n = 30)

| Year of Involvement | Frequency (F) | percentage (%) |
|---|---|---|
| Less than 5 Year | 5 | 16.7 |
| 5 - 10 Year | 8 | 26.7 |
| 10 - 15 Year | 10 | 33.3 |
| More than 15 Year | 7 | 23.3 |

### Work-Related Health Hazards Faced by the Farm Workers in the Tomato, Broccoli and Garlic Vegetable Production System

Sunburn was ranked the highest, followed by shoulder pain, pain in hands, joint pain, land preparation, nursery preparation, sowing, and irrigation in tomatoes, broccoli and garlic vegetable. Numbness in the finger was observed in the irrigation activity of all three crops. Among all the selected health hazards, upper back, lower back, joint pain, shoulder pain, and pain in hand was observed in transplanting, weeding, and harvesting tomato, broccoli, and garlic vegetable.

### Body Part Discomfort Faced by the Farm Workers in the Tomato, Broccoli and Garlic Vegetable Production System

Corlett and Bishop (1976) body part discomfort (BPD) scale is a subjective symptom survey tool consisting of a range from 1 to 10. Moderate discomfort was experienced by farm workers during various activities of the vegetable production system. It was found that the pain was observed highest in the elbow, hand, neck lower back, upper back, shoulder, ankle and feet during transplanting, weeding, irrigation and harvesting. In the sowing operation, the intensity of the pain was seen highest in the lower back, followed by the upper back, knees, legs, shoulder, neck, etc. While, spreading manure activity, farm workers reported that moderate discomfort was observed in the hand, upper back, shoulder, elbow, neck, wrist, lower back, ankle and legs, experienced by the farm workers.

### Application of REBA, OWAS and RULA for Postural Analysis

The OWAS technique (Ovako Working Posture Analyzing System) was developed by Heinsalmi (1986). One of the most important risk factors for musculoskeletal diseases at work is poor posture (WMSDs). According to scores of RULA and REBA, it was observed that working postures in various activities of the vegetable production system showed that the farm workers were working in a poor posture with a risk of injuries. The majority of farm workers in land preparation, nursery preparation, sowing and transplanting activity found each of the respondents obtained RULA scores of 5-6 (Action level 3) indicating that it required further investigation and change soon in tomato, broccoli and garlic cultivation. In tomato, broccoli and garlic cultivation in transplanting, weeding and harvesting activity observed REBA score 8-10 (high risk). It is indicated that the postures assumed by the farm workers during these operations with REBA score 8-10 require investigation implement change may be required in near future.

TABLE 2

Diagrammatic representation of different postures adopted by the farmworkers while performing different activities in the tomato, broccoli, and garlic vegetable production system

| Activities | Type of posture | Illustration | Postural analysis | | | | |
|---|---|---|---|---|---|---|---|
| | | | REBA | | OWAS | RULA | |
| | | | score | Risk level | Code (description) | score | Action category |
| Land prepration | Bending and Squatting (Tomato, broccoli and garlic) | The worker bends his upper back and out-stretches both arms below shoulder level, his back bent and twisted or bent forward and sideways, his hands hitting the earth to make it homogeneous for the next operation. | 10 | High risk (Investigate and implement change) | 2121 (Corrective action is required soon) | 6 | Further investigation and changes are required soon |
| Nursery prepration | Bending and Squatting (Tomato, and broccoli) | Squatting and bending are the most common positions, with both arms below shoulder level, both legs bent, and both hands stretched out to beat the earth. | 7 | Medium risk (Further investigation, change | 3141 (Corrective action should be done as soon as possible) | 6 | Further investigation and changes are required soon |
| Sowing | Bending (Tomato, broccoli, and garlic) | The worker sits in a crouching stance with both arms below shoulder level and the right hand stretched outstretching to scatter the seeds. | 5 | Medium risk (Further investigation, change soon) | 2121 (Corrective action is required soon) | 6 | Further investigation and changes are required soon |
| Transplanting | Bending and Squatting (Tomato, and broccoli) | To plant the seedlings, the worker sits in a crouching stance with a small bend in the neck and upper back, twisted posture, and hand extending below shoulder level. | 11 | High risk (Investigate and implement change) | 2121 (Corrective action is required soon) | 7 | Immediate change is required |

| Activities | Type of posture | Illustration | Postural analysis | | | | |
|---|---|---|---|---|---|---|---|
| | | | REBA | | OWAS | RULA | |
| | | | score | Risk level | Code (description) | score | Action category |
| Weeding  | Standing and bending (Tomato, broccoli, and garlic) | In this procedure, the worker bends and squats, both arms below shoulder level, back bowed and twisted or bent forward and laterally. | 11 | High risk (Investigate and implement change) | 2141 (Corrective action should be done as soon as possible) | 6 | Further investigation and changes are required soon |
| Irrigation  | Standing and bending (Tomato, broccoli, and garlic) | Watering the plant using funnel irrigation, the worker bends with the upper back as well, outstretching both arms below shoulder level, back bowed and twisted or curved forward and sideways. | 10 | High risk (Investigate and implement change) | 2131 (Corrective action is required soon) | 6 | Further investigation and changes are required soon |
| Spreading of manure  | Standing (Tomato, broccoli, and garlic) | The worker stands and bends forward, both arms below shoulder level, spreading fertilizer in the vegetable plant with the right hand. | 5 | Medium risk (Further investigation, change soon) | 2132 (Corrective action is required soon) | 4 | Further investigation and changes are required soon |
| Harvesting/ Plucking  | Standing and bending (Tomato, broccoli, and garlic) | The worker bends with the upper back as well, outstretching both arms below shoulder level, back bent and twisted or bent forward and sideways, to harvest garlic from the ground. | 11 | High risk (Investigate and implement change) | 4141 (corrective action for improvement required immediately) | 7 | Immediate change is required |

TABLE 3

Multiple regression analysis of age, BMI and years of involvement of the respondents with work-related health hazards in tomato, broccoli and garlic vegetable cultivation

| Work-related health hazards | Multiple regression values of different vegetable | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Tomato | | | Broccoli | | | Garlic | | |
| | Coefficient | "t" stat | "p" value | Coefficient | "t" stat | "p" value | Coefficient | "t" stat | "p" value |
| Constant | 1.915 | 14.858 | 3.2182E-14* | 2.086 | 17.871 | 4.0066E-16* | 2.182 | 13.303 | 4.1285E-13* |
| Age | -.057 | -2.637 | .014 | -.047 | -2.391 | .024 | -.081 | -2.948 | .007 |
| BMI | .027 | 1.102 | .281 | .008 | .365 | .718 | .004 | .128 | .899 |
| Years of involvement | -.002 | -.115 | .909 | .012 | .923 | .364 | -.002 | -.086 | .932 |

*Significant at 0.05 level

**Multiple Linear Regression Analysis of Work-Related Health Hazards**

For the present study, the independent variables considered were age (in years), BMI (body mass index) and years of involvement (in years) of the respondents, and the dependent variables were WRHH (Work-related health hazards) in vegetable cultivation. By considering

Age of the respondent = $x_1$

BMI of the respondent = $x_2$

Years of involvement of the respondent = $x_3$

the following regression lines in tomato cultivation

$$WRHH = 1.915 - .057x_1 + .027x_2 - .002x_3$$

the following regression lines in broccoli cultivation

$$WRHH = 2.086 - .047x_1 + .008x_2 + .012x_3$$

the following regression lines in garlic cultivation

$$WRHH = 2.182 - .081x_1 + .004x_2 - .002x_3$$

The 'p' value is found to be highly significant for the age of the respondent, which indicates that the age of the respondents has a high impact on work-related health hazards of the respondents. Therefore, we accept the above hypothesis. As the age of the respondents increases the work-related health hazards among them become severe and prominent. So, it can be concluded that the work-related health hazards of farm workers become more prominent with the increase of age.

**Multiple Linear Regression Analysis of Body Part Discomfort**

For the present study, the independent variables considered were age (in years), BMI (body mass index) and years of involvement (in years) of the respondents, and the dependent variables were BPD (body part discomfort) in vegetable cultivation. By considering

Age of the respondent = $x_1$

BMI of the respondent = $x_2$

Years of involvement of the respondent = $x_3$

the following regression lines in tomato cultivation

$$BPD = 2.060 - .018\,x_1 + .050\,x_2 - .019\,x_3$$

the following regression lines in broccoli cultivation

$$BPD = 1.944 - .025\,x_1 - .022\,x_2 + .016\,x_3$$

the following regression lines garlic cultivation

$$BPD = 2.023 - .028\,x_1 - .035\,x_2 + .018\,x_3$$

The 'p' value is found to be not significant for age, BMI and year of involvement of the respondent. Therefore, we reject the above hypothesis. So, it can be concluded that there is no significant relationship between age, BMI and years of involvement of the respondents with body part discomfort experienced by the respondents in vegetable cultivation of tomato, broccoli and garlic.

In the vegetable production system, farm workers play an important role in the entire vegetable growing

TABLE 4

Multiple regression analysis of age, BMI, and years of involvement of the respondents with body part discomfort in tomato, broccoli, and garlic vegetable cultivation

| Body part discomfort | Multiple regression values of different vegetable | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Tomato | | | Broccoli | | | Garlic | | |
| | Coefficient | "t" stat | "p" value | Coefficient | "t" stat | "p" value | Coefficient | "t" stat | "p" value |
| Constant | 2.060 | 6.716 | 3.9832E -7* | 1.944 | 6.913 | 2.437E -7* | 2.023 | 6.349 | 4.1285E -13* |
| Age-.018 | -.344 | .734 | -.025 | -.539 | .594 | -.028 | -.523 | .605 | |
| BMI | .050 | -.876 | .389 | -.022 | -.427 | .673 | -.035 | -.596 | .556 |
| Years of involvement | -.019 | .552 | .586 | .016 | .500 | .621 | .018 | .506 | .617 |

*Significant at 0.05 level

process, from land preparation to harvesting. Farm workers are engaged in various activities such as land preparation, nursery preparation, seeding, transplanting, weeding, irrigation, spreading of manure and harvesting. Except for ploughing, women are also actively participating in various farm operations such as seedling uprooting, transplanting, weeding, hoeing, harvesting, picking, threshing, winnowing, sieving, cleaning and storing grains. All activities are manual labor-oriented and farm workers are exposed to a variety of hazards that are potentially harmful to their health and wellbeing. Most of the tasks of vegetable cultivation are monotonous, strenuous, physiologically demanding as well as time-consuming. The physical demand of the farm workers ranges from moderate to heavy. Often including standing, squatting, bending, reaching, carrying heavy loads and working for long hours may bring certain hazards to the farm workers. The study aims to evaluate the task-specific postural strain associated with vegetable production systems such as land preparation, transplanting, weeding, irrigation, and harvesting which involve awkward static posture and upper extremity intensive activity.

The purpose of combining ergonomics with farm workers who are engaged in the vegetable production system is to reduce drudgery and provide an appropriate working environment that enhances their working capacity as well as productivity. Postural stress might be the reason for the occurrence of musculoskeletal discomfort. So, there is a need to provide ergonomics interventions that are required to modify their working posture and workplace orientation. Proper postural adoption and work-rest cycle may mitigate the work stress. From this study, it is recommended that workers should avoid bad work posture as far as possible during work for reducing job-related health hazards.

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