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Research Paper

Sapling transplanter : An effective tool for drudgery mitigation of women in vegetable production system

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■ **ABSTRACT :** This study was conducted with an aim to assess the drudgery faced by women while doing transplanting in conventional way and compare it to the improved method using hand-operated sapling transplanter along with the sapling holding basket. For the field experiments, thirty female subjects were selected in the age group of 25- 45 years. The drudgery was assessed in terms of postural load using survey tool RULA and physiological stresses were measured in both the transplanting methods. The results revealed that with conventional method respondents performed this activity in standing-cum-forward bending posture, with shoulder, head, neck and hip flexion whereas with the hand-operated sapling transplanter the activity is performed in standing posture with slight bending of the neck. Mean value of working heart rate was assessed to be 109.4 beats/ min. in conventional transplanting and 97.5 beats/ min with sapling transplanter. Similarly, values of Total Cardiac Cost Work (1065.73 beats), Physiological Cost of Work (35.4 beats/ min.), energy expenditure rate (10.20 kJ/min) in conventional transplanting of vegetables were reduced to 797.7 beats, 22 beats/min and 8.62 kJ/min, respectively with the use of sapling transplanter. The results of the body map technique for pain indicator revealed that severe pain was felt in lower back by 66.7 % respondents, upper back (46.7 % respondents), fingers and feet (43 %), whereas with the use of hand-operated sapling transplanter the intensity of pain was reduced to a great extent in majority of respondents. So, sapling transplanter along with the sapling basket proved to reduce the drudgery of farm workers.

■ **KEY WORDS:** Drudgery, Cardiac cost of work, Physiological cost of work, Postural stress, Musculoskeletal discomforts

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India is blessed with diverse agro-climates with distinct seasons, making it possible to grow wide array of vegetables. It is the second largest producer of vegetables in the world, after China. India produces 14 % (146.55 million tons) of world's vegetables on 15 % (8.5 million hectares) of world area under vegetables. Productivity of vegetables in India (17.3t/ha) is less than the world average productivity (18.8t/ha) in 2012-2013. (Indian Institute of Vegetable Research, 2015) Punjab is a leading state in terms of production of vegetables. Most of the vegetables like tomato (*Solanum lycopersicum*), and peppers (*Capsicum* spp.) are first sown in nursery

beds and later transplanted manually either on ridges or on a well prepared seedbed. The transplanting operation is one of the most labor intensive in vegetable production system. It is largely done manually in India and most developing countries and incurs large investments in labor, time, and cost. Most of the farm women are doing transplanting of vegetables with traditional methods like *kudal*, *khurpa* or by hands. The women work in either standing-cum- bending or squatting posture for transplantation and it is a repetitive activity performed for long duration. Working in this posture can cause work-related musculoskeletal disorders. Musculoskeletal disorders is one of the leading causes of occupational health hazard and disability in the developed and industrially developed countries (Genaidy *et al*., 1993). The development or modification of small drudgery reducing tools are need of the hour for Indian farmers to overcome the problem to easily manage basic farm operations like transplanting with change in posture and obviously labour and time saving. The hand-operated sapling transplanter is designed to do the transplanting of vegetables in standing posture. In this study, an effort is made to test the hand-operated sapling transplanter in terms of drudgery reduction. Therefore, the present study was conducted with the following objectives:

– To analyze the work postures adopted by women in transplanting activity both with the traditional method and by using handheld sapling transplanter.

– To assess the physiological stresses and muscular pains of women workers while performing the activity with both the methods.

■ RESEARCH METHODS

Locale of the study:

The study was conducted in *Malerkotla* town of Ludhiana district and Vegetable Farm of Punjab Agricultural University Ludhiana.

Selection of sample:

For the ergonomic evaluation, thirty female subjects were selected in the age group of 20-55 years with average to good health status and normal physiological parameters.

Procedure :

The time duration for performing the activity was half an hour with both the methods. Work postures were analyzed using RULA technique. Physiological parameters like heart rate, energy expenditure; Total cardiac cost of work and Physiological cost of work were measured in both the transplanting methods. Body Map technique was used to assess the musculoskeletal problems and intensity of pain in different body parts resulting from postural discomfort.

Postural asnalysis :

The Rapid Upper Limb Assessment technique (McAtamney and Corlett, 1993):

The RULA technique was proposed to provide a quick assessment of the loading on the musculoskeletal system due to postures of the neck, trunk, and upper limbs, muscle function, and the external loads exerted. Based on the total score of its coding system, four action levels, which indicate the level of intervention required to reduce the risks of injury due to physical loading on the worker, were suggested : Action level 1: Posture is acceptable; Action level 2: Further investigation is needed and changes may be needed; Action level 3: Investigation and changes are required soon; Action level 4:Investigation and changes are required immediately.

Measurement of physiological parameters :

Heart rate:

It was measured using heart rate monitor at rest, during the period of activity and recovery thereafter.

Energy expenditure:

Energy expenditure was estimated from the values of average heart rate during work by using following formula given by Varghese *et al.* (1995)

Energy expenditure (kj/min.) = 0.159 X average heart rate (beats/min.) - 8.72

Total cardiac cost of work (TCCW):

Total cardiac cost of work was determined by using average heart rate during rest and work, recovery heart rate and duration of work and recovery. The fomula for TCCW is :

Total cardiac cost of work = Cardiac cost of work + Cardiac cost of recovery

TCCW = CCW + CCR

CCW = (Average working heart rate – Average resting heart rate) x Duration of work

CCR = (Average recovery heart rate – Average resting heart rate) x Duration of recovery.

Physiological cost of work (PCW) :

$$\text{Physiological cost of work} = \frac{\text{Total cardiac cost of work}}{\text{Total time of activity}}$$

Musculoskeletal discomforts :

To assess the musculoskeletal discomforts and intensity of pain in different body parts after performing the activity, Body Map was used (Corlette and Bishop, 1988). The intensity of pain reported in each body part was determined on a five point scale ranging from very severe pain to very mild pain. Percentage of respondents having pain in different body parts was recorded.

Analysis of data:

Simple averages, percentages and mean scores were calculated and the results are presented in the form of tables. Frequencies and mean scores were calculated for analysis of data regarding musculoskeletal disorders.

■ RESEARCH FINDINGS AND DISCUSSION

The results of the present study are given below:

Personal details of the respondents:

The average age of the respondents was found to be 36 years. Regarding their education level more than 70 % of the respondents were below matric level, 98% were married and 60 % of the respondents were living in their own house.

Table 1 shows the comparison between both the transplanting methods. The area selected and the number of saplings to be transplanted were kept constant. The results revealed that the time spent in transplanting with the handheld transplanter was less as compared to the traditional method. Moreover, if the transplanting is done in the mulch soil, no extra time is required to make hole in the mulch. Thus, it can be said that with the use of handheld sapling transplanter, productivity is more in less time. Mahajan *et al.* (2014) also found out that when the harvesting of brinjal was done by improved method the pace of work increased by 19.96 per cent thus increasing the work output.

Table 2 reveals that by transplanting with the traditional method, the respondents were working in a poor posture with a risk of injury from their work posture, therefore there is a need to investigate and make change immediately. When transplanting was done with hand operated transplanter the score was 3.5 which suggests that the subject is working in a posture that could present some risk of injury to the person. One or the other body part is in awkward position, so this should be investigated and corrected. Mattila and Vilkki (1999) also concluded that more suitable work postures may have a positive effect on workers' musculoskeletal systems and may allow for more effective control of work performance

Table 1 : Comparison between transplanting with traditional method and hand operated sapling transplanter (n=30)

Sr. No.	Particulars	Traditional method	Hand ted transplanter
1.	Area covered	100m^2	100 m^2
2.	No. of seedlings transplanted	120	120
3.	Time of operation	42 min.	30 min.
4.	Time required for making hole on mulch soil	10 min.	-
5.	Posture adopted	Standing-cum-bending, squatting	Standing

Table 2 : Postural analysis using RULA technique (n=30)

Sapling transplantation in vegetable production system	Posture	Postural analysis using RULA		
		RULA score	Risk level	Action category
Traditional method 	Back bent forward, both arms below shoulder level, both knees bent weight/force needed 10 kg or less	7	Very high	Poor posture, investigate and change immediately
Use of hand operated transplanter 	Standing straight with neck bent forward, weight/force needed 10 kg or less	3.5	Low	Investigate further

Table 3 : Physiological workload of respondents by working in traditional method and by using sapling transplanter

Sr. No.	Physiological parameters	Traditional method (n=30)	Hand operated sapling transplanter method (n=30)
1.	Average resting heart rate, (beats/min.)	76.12	76.00
2.	Average working heart rate, (beats/min.)	109.4	97.5
3.	Peak heart rate (beats/min.)	114	103
4.	Average energy expenditure (kJ/min.)	10.20	8.62
5.	Average TCCW (beats)	1065.73	797.7
6.	Average physiological cost of work (beats/min.)	35.40	22.20

Table 4 : Specific pain and discomfort in different body parts of the respondents during transplanting activity

Sr. No.	Body parts	Presence of specific pain symptoms (Frequency and percentage of respondents)	
		Conventional method* (n=30)	Hand held sapling transplanter* method (n=30)
1.	Neck	9 (30%)	3(10 %)
2.	Shoulder	8 (26.7 %)	2(6.7%)
3.	Upper arm	3(10%)	-
4.	Lower arm	10 (33.3%)	5 (16.7 %)
5.	Wrist	7(23.3%)	2(6.7%)
6.	Palm	11(36.7%)	4(13.3%)
7.	Fingers	13(43.3%)	6 (20 %)
8.	Upper back	14(46.7%)	-
9.	Lower back	20(66.7%)	3(10 %)
10.	Hipps	5(16.7%)	-
11.	Thighs	12(40%)	-
12.	Upper legs	2(6.7%)	-
13.	Lower legs	3(10%)	1(3.33 %)
14.	Ankles	8(26.7%)	-
15.	Feet	13(43.3%)	5 (16.7 %)

*multiple responses

and reduction in the number of occupational injuries (Ansari and Sheikh, 2014; Nauriyal, 2006 and Singh, 2012).

Table 3 reveals that the mean value of working heart rate was assessed to be maximum 109.4 beats/ min in manual transplanting and 97.5 beats/ min with sapling transplanter. Total Cardiac Cost Work was found to be 1065.73 beats for manual transplanting of vegetables and 797.7 beats by the use of sapling transplanter. The Physiological Cost of Work was calculated as 35.4 b/ min. in traditional method and 22.2 b/min. in improved method. The energy expenditure rate was measured 10.20 kJ/min in manual transplanting method and reduced to 8.62 kJ/min with hand operated transplanter. According to Varghese *et al.* (1994) values of heart rate between 106-120 b/min. is considered to be moderately heavy workload and energy expenditure between 10.1 – 12.5 kj/min. is considered to be heavy workload. Hence, the hand operated sapling transplanter is proved to be drudgery reducer but addition of sapling carry basket is required for holding saplings/ nurseries. Gandhi *et al.* (2007) studied ergonomic assessment of bundling activity reported that bundling consisted of three sub-activities *i.e.* collection and preparation of tying material, collection of straws and tying of bundles; out of which tying of bundles was considered as heavy activity due to increasing values in heart rate and energy expenditure.

The pain and discomfort in lower back was felt by 66.7% of the respondents due to squatting posture in traditional transplanting followed by upper back (46.7%), feet (43.3%), fingers (43.3%), thighs (40%), palm (36.7%), neck (30%) ankles (26.7%), shoulder (26.7%), wrist (23.3%), hips (16.7%) and upper legs (6.7.%) of respondents, respectively. Awkward posture, lifting, forceful movement and manual work at rapid rate contribute to musculoskeletal disorder (Singh, 2012). It was found that pain and discomfort was comparatively low while using hand operated vegetable sapling transplanter. Only 16.7 % respondents felt pain in lower arm, palm (13.3%), lower back (10%) and shoulder (6.7%). This revealed that the women suffered from pain and discomfort more in lower back, Upper back

and feet due to manual transplanting method, however, the pain was reduced when the activity was performed with hand-operated sapling transplanter in standing position.

Conclusion :

The safety of the farm women and productivity of the produce in any production system is essential. The farm women perform multiple tasks in a traditional way due to lack of updated knowledge and skill. There is a need to design easily available and cost effective tools for maximum output. This study was an attempt in this direction. So, through results, it can be concluded that among the two methods, the transplanting of vegetable saplings done with the hand operated transplanter was found to be comfortable and light work based on the workload. It improves the work posture and thus reduces the physiological stress of the workers.

A sapling carry basket was developed for ease of carrying saplings and reduction in frequency of bending and picking saplings.

This basket is light in weight, attached in front and has adjustable straps that wrap uniformly and are evenly distributed over shoulders and waist to fit any user. It reduces drudgery while carrying saplings of vegetables and reduces the frequency of bending and standing up posture by 100 %.

Recommendation :

This hand operated vegetable sapling transplanter and sapling carry basket is helpful in mulch soil for transplanting vegetable, flowers and fruits saplings.

It saves time and improves posture from standing cum bending/squatting to standing (more comfortable) while doing transplantation.

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