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Developing Sapling Carrier for Hand Lever Operated Trans-Planter

Jayshree P. Zend[1], Manjusha S. Revanwar[2]

College of Community Science, VNMKV Parbhani-431402, Maharashtra, India

Abstract: ***Ergonomic assessment of manual hand trans-plantation and transplanting activity with new technology package i.e. sapling carrier and seedling trans-planter in chilly and brinjal production system was carried out with 30 healthy farm women having minimum 8 years' experience of transplanting. Field experiment was carried out in selected fields from six villages of Parbhani district. Chilly (Ankur 930) and brinjal (Ajay- Ankur) crops were selected for the experiment. Type of soil, soil condition, bund height and length, row to row and plant to plant spacing, type of irrigation, use of mulching paper was planned before the experiment in consultation with farmers and agricultural scientists. Study revealed that manual hand transplanting and trans-planter method were at par with respect to productivity out-put factors. Physiological work load of transplanting activity was reduced significantly (18 %) when work was performed with trans-planter and seedling carrier .With respect to posture and muscle skeletal disorder in trans- planter method, there was significant reduction in angle of deviation and level of pain at neck, wrist and lower back. Perceived rating on time load indicated that trans-planter method was moderately heavy and as per the perceived rating on exertion, it is light task. Strain index for both the hands in improved method were similar. Strain index of right hand in conventional method was highest i.e. 8.04 indicated that job was probably hazardous. Grip strength of the right hand of the worker was reduced in conventional method i.e. right hand was more fatigued. On the whole it can be concluded that transplantation by conventional method is hazardous for the farm women whereas use of sapling carrier with trans-planter was helpful in reducing drudgery and making job safe.***

Keywords: Transplanting, strain index, ergonomic evaluation, perceived exertion

1. Introduction

The workers adopt long static postures for some of the activities, which increase the static muscular effort resulting in physiological cost and low productivity. The use of traditional method for work adds to further their drudgeries. The postures adapted by the workers in their working place depends upon the type of work, the design of work place, personal characteristics, the tools required to perform the particular work and also the duration and frequency of the work cycle (Bridger, 1995 ; putz-Anderson, 1988). Farmers use traditional methods of transplanting i.e. by hand which is time and labour consuming .It is very difficult for them to acquire costly agricultural machinery and equipments (R. Manzoor *et al* 2016).

There is a need of cheap and easily available farm machinery to reduce human efforts, time consume and damage done to crops while transplanting. Numerous trans-planters are accessible in business sector. The handheld trans-planter is also used for cultivation purposes. It consists of components like handle, lever, hollow pipe, jaw and jaw operating wire. The main advantage of the handheld trans-planter is that it reduces postural load of worker. But there was a need of an accessory for carrying saplings while performing transplanting activity with the help of trans-planter. Therefore this project was focused on ergonomic assessment of transplanting activity with new technology package i.e. sapling carrier and trans-planter in the selected production system. The objectives of the experiment was to assess ergonomically manual hand trans-plantation and trans-planting activity with new technology package.

2. Methodology

Ergonomic evaluation of selected farm activity

Total 30 healthy, non-pregnant, non-lactating farm women without symptoms of cold and fever working in the field for 6 hrs/ day and 6 days/ week and having minimum eight years experience of transplanting were selected for the study. Transplanting activity was performed with existing and improved method in three replications.

Equipments used for the study

Polar heart rate monitor, Anthropo-meter, Sphygmomanometer, grip dynamometer, Hygrometer, Dry & wet bulb thermometer, Suryamapi

Measurement of Parameters

Average working Heart Rate **(**b.m^{-1}) (AWHR): Working heart rate was recorded with the help of heart rate monitor at every three minutes till the completion of activity. Average Peak Heart rate **(**b.m^{-1}) (APHR): It was noted down while performing the activity.

a) Average & peak energy expenditure **(**kj.m^{-1}) (AEE & APEE): It was calculated by using following formula.
EE **(**kj.m^{-1}) = 0.159 X Heart rate **(**b.m-^{1}) -8.72
b) Total cardiac cost of work (TCCW): TCCW was calculated by using the following formula

TCCW = Cardiac cost of work + Cardiac cost of recovery
where,
Cardiac cost of work (CCW) = (Average working heart rate – Average resting heart rate) X duration
Cardiac cost of recovery (CCR)=(Average recovery heart rate–Average resting heart rate) X duration

c) Physiological cost of work (PCW): It was calculated by following formula PCW = TCCW / Total time of work
d) Strain index of upper limbs was measured by using scales developed by Moore & Garg (1995) for both improved and conventional method

e) Scales used for interpretation of scores

RPE (Rated perceived exertion)	Work related drudgery experience
Very heavy -5	Very demanding-5
Heavy-4	Demanding -4
Moderately light-3	Moderately demanding-3
Light-2	Less demanding -2
Very light-1	Very less demanding-1

Physical load	Time load rating
Very heavy-5	Very slow -5
Heavy -4	Slow -4
Moderately heavy-3	Moderately -3
Light-2	Fast -2
Very light-1	Very fast -1

Details of the field

Location of the study	Pokharni, Itlapur, Brahamangaon, Raipur and Khanapur, Dist. Parbhani
Production system	Vegetable production system
Name of the crop and Seed variety	Chilly (Ankur-930) and Brinjal (Ajay-ankur)
Soil type	Black cotton
Bunds Height	0.23m
Bund length	40 m
Row to row Spacing	0.6 m
Plant to plant spacing	0.6 m
Type of land	Conventional- Wet
	Trans-planter- Dry
Prepared soil condition after tillage	Loose without stubbles
Area formation for transplanting saplings	Conventional - Bund sowing
	Trans-planter- Mulch sowing (White
	Plastic Mulching paper of 30 micron thickness and 1.23m width)
Type of irrigation	Conventional - Flood and Drip
	Trans-planter- Drip

Details of the improved and conventional transplanting methods

a) Conventional Transplanting Method: Transplanting of sapling was performed only by farm women. Conventional transplanting was manual sapling transplantation which is performed continuously by hand in bending posture. In conventional transplantation, field is irrigated before transplanting.

b) Improved method: Trans-planter recommended by PJTS Agricultural University was procured from M/S Anjali veg. co-op society, Hyderabad. It is a light weight (1.74 kg) stainless steel implement which can easily be operated in standing posture while transplanting the saplings. Sapling carrier was developed by AICRP FRM Unit, College of Home Science VNMKV Parbhani. Purpose of sapling carrier was to facilitate sapling transplantation in standing position. It is a HDPE plastic fiber tarpaulin bag which can easily be tied at waist level of the worker. The bag is designed in such a way that it remains open all the time. The trans-planter requires use of both hands simultaneously. Sapling carrier needs to be provided, so that both hands remain free.

3. Results and Discussion

Physical characteristics of the farm worker involved in transplanting activity

Physical characteristics of the farm workers such as age, height and body weight were recorded and Body Mass Index (BMI) and aerobic capacity (VO_2 max) was calculated. Average age of the selected farm women was 38 years with 150 cm average height and 46 kg average body weight. Majority (76.66 %) of the selected farm women belonged to normal weight category (BMI- 18.5 to 24.99), only one woman was overweight and 20 per cent were under weight. It indicated that on an average 23 per cent selected farm women were weak. It was found that 46.66 per cent farm women were having good aerobic capacity (31- 40 ml/ kg/ min). It was followed by 33.33 per cent belonged to high average (26 to 30 ml/ kg/ min) and 13.33 per cent low average (16.25 ml/ kg/ min). Only two women (6.6 %) had excellent VO_2 max (beyond 45 ml/ kg/ min). It was concluded that 75 per cent of the selected farm women belonged to normal category of BMI, and aerobic capacity.

Productivity output factors -Time & work

In conventional method, 351 saplings were transplanted per hour per worker, whereas with trans-planter and sapling carrier, 341 saplings were transplanted per hour/worker (Table 1). Total time estimated for transplanting one hector area by conventional method was 67 hrs and that of for trans-planter with sapling carrier method was 66 hrs. Total man days considered necessary were same for transplanting 1 hector field i.e. eight days for both conventional and trans-planter methods. Statistical analysis revealed that there was no significant difference between pace of work for transplanting one hector area by conventional and trans-planter method. Perceived ratings by workers on time load indicated that conventional and trans-planter and sapling carrier methods were moderately heavy tasks. Perceived ratings on time load differ significantly in conventional and trans-planter method. Hence, it is concluded that manual hand transplanting and trans-planter method are at par with respect to productivity output factors.

Physiological load

Physiological parameters like Heart Rate, Energy Expenditure, TCCW and PCW were measured in the conventional and improved method (Table 2). Value of working heart rate was maximum 106 $\pm$ 6.9 bm^{-1} in manual hand transplanting and it was 103 $\pm$ 10 bm^{-1} with trans-planter and sapling carrier. The energy expenditure calculated in conventional transplanting method was 8.09 $\pm$ 1.1 kj/m and was reduced to 7.58 $\pm$1.5 kj/m i.e. 6 percent reduction, when work was carried out with trans-planter and sapling carrier. TCCW was found to be 373 $\pm$ 166.6 beats for manual hand transplanting of chilly and brinjal and there was 10 percent reduction in TCCW i.e. 334 $\pm$ 185 beats recorded when work was performed by the use of trans-planter and sapling carrier. The PCW was reduced by 18 percent in improved (27 $\pm$ 10.1 beats) over existing conventional method (33 $\pm$ 8.8 beats). Statistical test applied revealed that physiological cost of work of transplantation activity was significantly reduced when work was performed by the use of trans-planter and sapling carrier. Similarly peak heart rate (PHR) and energy expenditure (PEE) of

work were significantly reduced in improved method. PHR was reduced by 4 per cent and PEE was reduced by 9 per cent with trans-planter and sapling carrier method. Average RPE (4.3 score) of conventional method of transplanting indicated that conventional method of transplanting was perceived as heavy activity by the worker. Where as in case of trans-planter method, average RPE was reduced to 2.34 which indicated that work of transplantation of chilly and brinjal with the help of trans-planter and sapling carrier was moderately light. Statistically, there was significant difference between RPE of conventional and improved method.

Hence, it can be concluded that physiological load of transplanting chilly and brinjal in manual hand transplanting method was significantly higher than mechanical transplanting by sapling trans-planter and carrier. There was 18 per cent significant reduction in physiological cost of work when transplanting was performed with the help of trans-planter and carrier. Similarly perception of workers indicated that transplantation of chilly and brinjal with the help of trans-planter was moderately light activity as compared to manual hand transplanting.

Strain Index of upper limbs (Moor & Garg- 1995)

Strain index of upper limbs i.e. for left and right hand was calculated by using Moore and Garg scale (1995). Table 3 indicates that average intensity of exertion for right hand was maximum (3± 1.14) in conventional method as sapling cultivation is done by right hand in wet soil. Intensity of exertion was least in case of improved method (1.08±0.4). Statistical analysis indicated that there was highly significant difference in intensity of exertion in conventional and improved method of both the hands.

Duration of exertion was rated same for both the hands in both the selected methods of transplantation. Similar results were obtained for efforts per minute and speed of work and duration of task per day. With respect to hand and wrist posture rating was reduced significantly for both the hands in case of improved method. It indicated that hand and wrist posture was comfortable in case of improved method.

The value of strain index for left hand was lower than the right hand in both the methods. Strain index of the left hand was categorized as job may place individual at increased risk for distal upper extremity disorders in case of conventional and improved method. Strain index of right hand was highest i.e. 8.04, when the cultivation of sapling was done manually by hand. It indicated that job of manual cultivation is probably hazardous. Where as in case of improved method results were similar for both the hands. Statistical analysis showed that strain Index was significantly higher in conventional method for both the hands compared to trans-planter method.

On the whole it can be said that manual transplanting and mechanical transplanting may place individual at increased risk for upper limbs. Whereas if sapling transplantation is done by hand in wet soil which is probably hazardous for the workers.

Useful features of sapling carrier

- Made out of locally available material and can be made by local artisan
- Useful for increasing speed of transplanting
- Easy to wear
- Also useful for carrying seeds at the time of sowing by seed drill method

Table 1: Time and Work *(Productivity output factors)*, N=30

Particulars	Conventional method (Mean± SD)	Trans-planter method (Mean± SD)	"t" value
No. of Saplings transplanted/ h/worker (pace of work)	351± 123.43	341 ± 108.14	NS
Time required for transplanting (hr/h)	67± 36.8	66± 65.46	NS
Man days needed for trans-plating/h	8±4.58	8 ±8.21	NS
Perceived rating on time load by worker	2.9 ± 0.38 (Moderate)	2.6 ± 0.7 (Moderate)	2.14*

Perceived rating on time load: Very slow -5, Slow -4, Moderate- 3, Fast – 2 and Very fast -1

Table 2: Physiological load of farm women while performing transplanting activity with conventional and trans-planter method

Physiological parameters	Conventional (Mean ± SD)	Improved (Mean ± SD)	Reduction in improved over existing	't' value
Working heart rate (bm^{-1})	106 ± 6.9	103 ± 10.0	3 (02.83)	NS
Peak heart rate (bm^{-1})	115 ± 8.4	110 ± 10.4	5 (04.34)	2.049*
Energy expenditure (kjm^{-1})	8.09 ± 1.1	7.58 ± 1.5	0.51 (06.30)	NS
Peak Energy expenditure (kjm^{-1})	9.47±1.3	8.69±1.6	0.78 (08.23)	2.108*
CCW (Beats)	337 ± 145.5	312 ± 165.2	25 (07.41)	NS
CCR (Beats)	25 ± 32.7	15.0 ± 30.6	10 (40.00)	NS
TCCW (Beats)	373 ± 166.6	334 ± 185	39 (10.45)	NS
PCW (Beats)	33.0 ± 8.8	27 ± 10.1	6 (18.18)	2.45*
Average RPE	4.3 ±0.57	2.34 ± 0.65	1.9 (44.18)	12.72**

Figures in parenthesis indicates percentages,
**Significant at 1% level, NS-Non significant
CCW- Cardiac cost of work, CCR-Cardiac cost of recovery, TCCW-Total cardiac cost of work, PCW- physiological cost of work,
RPE- Rated perceived exertion : Very light - (1) , Light - (2), Moderately light - (3) , Heavy - (4) , Very heavy - (5)

Table 3: Strain Index of Upper limbs (Moore and Garg, 1995) of farm women while performing transplanting activity with conventional and trans-planter method

Risk factors	Left hand		't' Value	Right hand		't' Value
	Conventional method	Improved method		Conventional method	Improved method	
Intensity of exertion	1.4±0.8	1.0±0.0	2.73**	3.0±1.14	1.08±0.4	8.72**
Duration of exertion	0.5±0.0	0.5±0.0	NS	0.5±0.0	0.5±0.0	NS
Efforts per minute	1.25±0.3	1.16±0.2	NS	1.25±0.3	1.16±0.2	NS
Hand/wrist posture	1.43±0.16	1±0.0	15.35**	1.47±0.17	1.0±0.0	15.16**
Speed of work	1.06±0.1	1.06±0.1	NS	1.06±0.1	1.06±0.1	NS
Duration of task per day	0.75±0.0	0.75±0.0	NS	0.75±0.0	0.75±0.0	NS
Strain Index	6.41 ± 0.88	5.47 ± 0.32	5.52**	8.04±1.26	5.56±0.48	10.08**

Result key
SI≤3 : Job is probably safe
3<SI<7: Job may place individual at increased risk for distal upper extremity disorders
7<SI :Job is probably hazardous
*Significant at 5% level,
**Significant at 1% level, NS-Non significant

Hand lever operated stainless steel trans-planter (90 cm height and 1.76 kg weight)

Waist tie sapling carrier (made up of tarpaulin)

Conventional method of sapling transplantation

Transplantation with trans-planter and sapling carrier

4. Conclusion

Study revealed that manual hand transplanting and trans-planter method were at par with respect to productivity out-put factors. Physiological work load of transplanting activity was reduced significantly (18 %) when work was performed with trans-planter and sapling carrier. Perceived rating on time load indicated that trans-planter method was moderately heavy and as per the perceived rating on exertion, it is light task. Strain index for both the hands in improved method were similar. Strain index of right hand in conventional method was highest i.e. 8.04 indicated that job was probably hazardous. On the whole it can be concluded that transplantation by conventional method is hazardous for the farm women whereas use of trans-planter with sapling carrier was helpful in reducing drudgery and making job safe.

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