



# Promotion of Low-cost Package of Technologies for Drudgery Mitigation in Turmeric Production System

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. Author JPZ designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MSR and SSG managed the analyses of the study and managed the literature searches. All authors read and approved the final manuscript.*

## **Article Information**

DOI: 10.9734/JSRR/2020/v26i130208

### Editor(s):

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Complete Peer review History: <http://www.sdiarticle4.com/review-history/54004>

**Original Research Article**

**Received 10 November 2019**

**Accepted 16 January 2020**

**Published 06 February 2020**

## **ABSTRACT**

Major role of farm women in the turmeric production system in Marathwada region was found to be in planting rhizomes, weeding, harvesting and cleaning activities. Ploughing, forming ridges, irrigation are performed solely by male farmers. Whereas participation of farm women in earthing up activity was 85 per cent, it was followed by fertilizer application (83%). Majority of the activities such as planting, earthing up, harvesting in turmeric production system were performed manually. Data on time spent by the female workers in performing different activities in turmeric production system indicated that maximum time-consuming activity was hand weeding (84 man-days/ season) followed by earthing up (63 man-days/ season) and cutting, sorting and cleaning roots (56 days/ season). As per the work demand score, all the activities performed in turmeric production system were very time demanding and very exhaustive as per the psychological feeling of the farm women. Earthing up is an important intercultural operation which is normally carried out twice or thrice during the crop season, accompanied by weeding and side dressing the crop with fertilizers. No tool or implement is used by farmers for earthing up activity. All the farmers were unaware of the hand-operated machines available for earthing up activity. After performing these activities continuously for 6 h, major health problems of the farm women reported were burning sensation to

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the skin, skin peeling and allergy. Hence, earthing up tool (*Sawdi*) small digging tool (*Ukari*), set of five finger guards (*Nakhalya*) for planting rhizomes, drying tool (wooden rake) (for making upside down while drying turmeric fingers), sulbha bag for fertilizer application, mittens for cleaning and sorting and new khurpi for weeding were developed and tested. The ergonomic assessment revealed that the physiological cost of selected activities performed by farm women in existing and improved method was same but the perception of workload was found to be reduced (13-32%) in an improved method. All the developed technologies used by farm women in the turmeric production system for planting, earthing up, fertilizer application and drying were successful in increasing space of work. In all these activities, the output was significantly increased by 10-26 per cent due to the use of developed technologies.

**Keywords:** Turmeric; drudgery; ergonomic assessment; earthing up; physiological cost.

## 1. INTRODUCTION

Turmeric (*Curcuma longa L*), the ancient and sacred spice of India known as 'Indian saffron' is an important commercial spice crop grown in India [1]. Turmeric is the dried rhizome of *Curcuma longa L.*, a herbaceous perennial belonging to the family Zingiberaceae and a native of South Asia particularly India [2,3,4]. In Maharashtra, total 6,760 h land was under the cultivation of turmeric crop in 2015-16.

Turmeric is available in two seasons in India i.e., February to May and August to October. The plant is propagated from rhizomes. The rhizomes are ready for harvesting in about 7 to 9 months after planting. Parbhani district is one of the eight districts in the Marathwada region of Maharashtra State. Here planting and earthing up activities are performed by the majority of the farm women in the traditional way [5].

Rhizomes are planted at 1/3rd height of ridge on a broad ridge. Planting is done with light digging [6,7]. About 8 inches depth small block is made by hand for planting rhizomes. Majority of women make the small block on ridges by hand. Hence, small digging tool and set of five finger guards were developed for planting rhizomes. Similarly, no tool or implement is used for earthing up activity. All the farmers were unaware of the hand-operated machines available for earthing up activity. After performing earthing up activity continuously for 6 h, major health problems of the farm women reported were burning sensation to the skin, skin coming out and skin allergy. Hence, earthing up tool was designed and tested.

## 2. PROCEDURE

Package of seven technologies developed was ergonomically tested under this project as follows.

**Chart 1. Package of the total of seven technologies**

S. No.	Name of the technology	Use
1.	Digging tool	Digging soil while
2.	Finger guards	planting turmeric rhizomes & fertilizer application
3.	Earthing up tool	Earthing up activity
4.	New khurpi	Weeding
5.	Fertilizer application bag	Fertilizer application
6.	Soybean mittens	Harvesting
7.	Wooden rake	Turning turmeric fingers while drying

### 2.1 Ergonomic Evaluation of Selected Farm Activity

A total of 30 healthy farmworkers working in the field for 6-7 hrs/ day and 6days/ week and having minimum five years' experience of work in turmeric production were selected for the study.

### 2.2 Mode of Data Collection

No. of female workers:	49
Field trials/Replications:	03
No. of farm activities:	06
No. of methods:	02

### 2.3 Equipment Used for the Study

Polar heart rate monitor, Anthropometry kit, Sphygmomano meter, Grip dynamometer, Hygrometer, Thermometer, Noise level meter and weighing balance.

**Measurement of parameters:** the following Measurement Parameters were used while making a questionnaire for the study.

- Average working Heart Rate ( $b.m^{-1}$ )
- Average Peak Heart rate ( $b.m^{-1}$ )

- Average & peak energy expenditure ( $\text{kJ.m}^{-1}$ )
- Total cardiac cost of work (TCCW)
- Physiological cost of work (PCW) [8].

## 2.4 Parameters Used to Assess the Drudgery Experiences

**RPE (Rated perceived exertion):** Very light (1), Light (2), Moderately light (3), Heavy (4), Very heavy (5) [9].

**Work-related drudgery experience:** Very demanding (5), demanding (4), Moderately demanding (3), Less demanding (2), Very less demanding (1).

**Physical load:** Very heavy (5), Heavy (4), Moderately heavy (3), Light (2), Very light (1).

**Postural load rating:** Very comfortable (5), Comfortable (4), Moderate (3), Discomfort (2), Very uncomfortable (1).

**Postural load rating.** Very slow (5), Slow (4), Moderate (3), Fast (2), Very fast (1) [10].

Location of the study	: Pokharni, Katneshwar, Nandgaon, Bharati Camp Dist. Parbhani & Hatta, Adgaon, Satephal villages of Dist. Hingoli
No. of farm activities assessed & subjects selected for the study	: Planting (10), Weeding (09), Earthing up (10), Fertilizer application (10), Harvesting, Sorting & cleaning (10) and drying (10)

## 3. RESULTS AND DISCUSSION

### A. General Information of the Respondents Working in the Turmeric Production System

Personal information such as age, cast, education, and family information such as landholding, occupation and annual income were noted down during the survey. It was found that selected women respondents were in the age range of 20 to 50 yrs. The average age of the respondents was 43 years. The small value of standard deviation i.e. 9.6 indicated that the selected sample was homogenous concerning age. On an average height of the selected farm women was 145.68 cm. Minimum bodyweight of the selected respondents was noted 35 kg and that of the maximum was 70 kg. Majority of respondents had performed agricultural activities

for more than 15 years and most of them were working for 4 to 8 h in the field. About 77 per cent of farm workers noted to be working for 7 days in a week.

About 50 per cent of the respondents were holding land more than 10 acres followed by 25 per cent were holding 5 to 10 acres. Majority of the land was dry and about 29 per cent of the land was irrigated. Majority of the respondents were working in own land whereas 36 per cent were working in leased land. Majority of the respondents belonged to the farming family, 33 per cent of the respondents were contractual labourers. Regarding the annual income of the family 42 per cent of the families had family income up to Rs.50,000/-. On an average annual income was Rs.64,346/-. The sample was heterogeneous about the income of the family. None of the selected family was having annual income more than Rs 200,000/-. Hence, it can be concluded that selected respondents were from farming families and they were full-time farmworkers.

### B. Drudgery Experience in the Production System

- a) Drudgery experience due to work demand and filling of exhaustion: As per the work demand score all the activities performed in turmeric production system were time demanding and very exhaustive as per the psychological feeling of the farm women.
- b) Posture assumed in work and frequency of the posture change: Majority of the selected farm women reported that posture adopted while working in the turmeric production system such as squatting and bending are very difficult, but as frequency of posture change was less, planting and hand weeding activities are performed continuously in squatting posture were perceived less difficult.
- c) Difficulty and workload perception: Majority of the selected farm women reported that many of the activities in the turmeric production system are very painful. Similarly, as per the workload perception, farmers categorized these activities as very heavy.
- d) Perception of manual load operatives: Perception of the manual load operative was based on the total load carried by farmworkers while performing activities in the turmeric production system. It was reported that in many of the activities less than 5 kg weight is carried, whereas during

fertilizer application and sorting turmeric roots 5 to 10 kg load needs to be carried.

**C. Physiological Load of Women Workers while Performing Planting Turmeric Rhizomes/Roots in Turmeric Farming System**

The physiological workload of the selected women workers while performing selected activities in turmeric production system was assessed by measuring energy expenditure. Selected parameters such as working heart rate, peak heart rate, energy expenditure, peak energy expenditure, cardiac cost of work (CCW), total cardiac cost of work (TCCW) and physiological cost of work (PCW) were compared in an existing and improved method. In improved method work was performed by the farmworkers with the help of developed tools such as two digging tools, earthing up tool, sulbha bag, new khurpi, mittens and wooden rake (Plate 1-7).

In case of planting, earthing up and manual fertilizer application, working heart rate and its corresponding parameters were found to be decreased but statistically, results were non-significant. In the case of weeding, average working heart rate of the farmworkers was found to be increased by 1 to 2 per cent. Statistical difference was not significant. Hence, it can be concluded that when work was performed with improved tools there was no significant decrease/increase in physiological workload (Tables 1-5). Rated perceived exertion was highest for planting and fertilizer application in existing the method. There was a significant decrease in RPE by 23-32 per cent in an improved method of planting, earthing up,

manual fertilizer application and in drying for making upside-down of turmeric fingers. In the case of hand weeding, there was no significant decrease in RPE (13%) was found (Table 6). All the selected activities in the turmeric production system were perceived as very heavy activities by all selected farm women except weeding. With improved tools, all respondents reported that the workload was reduced and farm activities were moderately heavy. In conclusion, it can be said that the physiological cost of selected activities performed by farm women in existing and improved method was the same. Perception of workload was found to be reduced in the improved method.

**D. Time and Work-study of the Selected Activities in the Turmeric Production System**

Time and work-study of the selected activities in turmeric production system revealed that planting rhizomes by using Ukari, earthing up activity with Sawadi, cleaning and sorting with mittens, drying with the help of wooden rake were significantly superior methods over existing methods. In all these activities, the output was significantly increased by 10-26 per cent. When manual fertilizer application was performed with the help of Sulbha bag, women workers covered 23 per cent more area per hour. Whereas in case of planting by using finger guards, 12.69 per cent more area was covered per hour by the farm women. It can be concluded that all the developed technologies used by farm women in the turmeric production system for planting, earthing up, fertilizer application and drying were successful in increasing pace of work (Table 7).

**Table 1. Physiological load of women workers while performing planting rhizomes/ roots in turmeric production system (N = 10)**

Particulars	Existing method (Mean ± SD)	Improved method (Mean ± SD)	Increase/ decrease improved over existing
Working heart rate (bm <sup>-1</sup> )	105 ± 15.5	103 ± 14.23	2 (1.9)
Peak heart rate (bm <sup>-1</sup> )	118 ± 17.88	114 ± 16.39	4 (3.38)
Energy Expenditure (kjm <sup>-1</sup> )	8.02 ± 2.46	4.72 ± 2.26	0.3 (3.74)
Peak Energy Expenditure(kjm <sup>-1</sup> )	10.08 ± 2.84	9.34 ± 2.6	0.74 (7.34)
CCW (Beats)	304 ± 123	254 ± 116.91	50 (16.44)
CCR (Beats)	32 ± 22.68	33 ± 29.55	-1
TCCW (Beats)	336 ± 142.21	287 ± 134.02	49 (14.58)
PCW (Beats)	34 ± 16.29	33 ± 18.22	1 (2.94)
Work load category as per heart rate	5 Very Heavy	3.4 Moderate	1.6 (32)
't' value(Existing Vs. Improved)	NS		

CCW - Cardiac cost of work, CCR - cardiac cost of recovery, TCCW-Total cardiac cost of work, PCW - Physiological cost of work, NS - Non significant; RPE-Rated perceived exertion, Figures in parenthesis indicates percentages

**Table 2. Physiological load of women workers while performing hand weeding in turmeric production system (N = 9)**

Particulars	Existing method (Mean ± SD)	Improved method (Mean ± SD)	Increase/ decrease improved over existing
Working heart rate (bm <sup>-1</sup> )	105 ± 8.7	106 ± 9.82	-1 (0.95)
Peak heart rate (bm <sup>-1</sup> )	116 ± 12.89	112 ± 12.83	4 (3.44)
Energy Expenditure (kjm <sup>-1</sup> )	8.01 ± 1.38	8.13 ± 1.56	- 0.12 (1.49)
Peak Energy Expenditure (kjm <sup>-1</sup> )	9.68 ± 2.04	9.1 ± 2.04	0.58 (5.99)
CCW (Beats)	297 ± 88.91	305 ± 101.44	- 8 (2.69)
CCR (Beats)	21 ± 20.37	31 ± 34.07	- 10 (47.61)
TCCW (Beats)	318 ± 102.77	336 ± 133.16	- 18 (5.66)
PCW (Beats)	32 ± 10.27	34 ± 13.31	- 2 (6.25)
Work load category as per heart rate	4 Heavy	4 Heavy	0
't' value (Existing Vs. Improved)	NS		

**Table 3. Physiological load of women workers while performing earthing up activity in turmeric production system (N = 10)**

Particulars	Existing method (Mean ± SD)	Improved method (Mean ± SD)	Increase/ decrease improved over existing
Working heart rate (bm <sup>-1</sup> )	118 ± 8.19	117 ± 15.82	1 (0.84)
Peak heart rate (bm <sup>-1</sup> )	126 ± 8.76	125 ± 16.35	1 (0.49)
Energy Expenditure (kjm <sup>-1</sup> )	10 ± 1.3	10 ± 2.5	0
Peak Energy Expenditure (kjm <sup>-1</sup> )	11 ± 1.39	11 ± 2.6	0
CCW (Beats)	587 ± 405.92	530 ± 144.53	57 (9.71)
CCR (Beats)	40 ± 12.37	39 ± 44.18	1 (2.5)
TCCW (Beats)	627 ± 404.12	570 ± 167.7	57 (9.09)
PCW (Beats)	45 ± 8.31	47 ± 19.81	-2
Work load category as per heart rate	5.0 Very heavy	4.0 Heavy	1 (16.66)
't' value(Existing Vs. Improved)	NS		

CCW - Cardiac cost of work, CCR - cardiac cost of recovery, TCCW-Total cardiac cost of work, PCW - Physiological cost of work, NS - Non significant; RPE-Rated perceived exertion, ures in parenthesis indicates percentages

**Table 4. Physiological load of women workers while performing manual fertilizer application activity in turmeric production system (N = 10)**

Particulars	Existing method (Mean ± SD)	Improved method (Mean ± SD)	Increase/ decrease improved over existing
Working heart rate (bm <sup>-1</sup> )	105 ± 15.5	103 ± 14.23	2 (1.9)
Peak heart rate (bm <sup>-1</sup> )	118 ± 17.88	114 ± 16.39	4 (3.38)
Energy Expenditure (kjm <sup>-1</sup> )	8.02 ± 2.46	4.72 ± 2.26	0.3 (3.74)
Peak Energy Expenditure (kjm <sup>-1</sup> )	10.08 ± 2.84	9.34 ± 2.6	0.74 (7.34)
CCW (Beats)	304 ± 123	254 ± 116.91	50 (16.44)
CCR (Beats)	32 ± 22.68	33 ± 29.55	-1
TCCW (Beats)	336 ± 142.21	287 ± 134.02	49 (14.58)
PCW (Beats)	34 ± 16.29	33 ± 18.22	1 (2.94)
Work load category as per heart rate	5 Very Heavy	3.4 Moderate	1.6 (32)
't' value(Existing Vs. Improved)	NS		

**Table 5. Physiological load of women workers while performing sorting & cleaning activity in turmeric production system (N = 10)**

Particulars	Existing method (Mean ± SD)	Improved method (Mean ± SD)	Increase/ decrease improved over existing	't' values
Working heart rate (bm <sup>-1</sup> )	99 ±6.7	95±7.11	4 (4.04)	NS
Peak heart rate (bm <sup>-1</sup> )	108±6.56	100±7.67	8 (7.40)	<b>2.5*</b>
Energy Expenditure (kjm <sup>-1</sup> )	7.06±1.06	6.38±1.13	0.68 (9.63)	NS
Peak Energy Expenditure (kjm <sup>-1</sup> )	8.38±1.04	7.49±1.22	0.89 (10.62)	NS
CCW (Beats)	225±87.72	164±61.7	61 (27.11)	NS
CCR (Beats)	19±11.31	10±5.62	9 (47.36)	<b>2.25*</b>
TCCW (Beats)	244±93.08	174±65.24	70 (28.68)	<b>NS</b>
PCW (Beats)	28.57±7.5	23.29±7.53	5.28 (18.48)	NS
Work load category as per heart rate	4 Heavy	2.8 Moderate	1.2 (30)	

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, NS - Non significant, \*- significant at 5%, \*\*- significant at 1%, Figures in parenthesis indicates percentages

**Table 6. Rating of perceived exertion (RPE) of farm women while performing selected activities in turmeric production system**

Name of the activity	Existing method (Mean ± SD)	Improved method (Mean ± SD)	Increase/ decrease improved over existing (%)	't' Values
Planting turmeric rhizomes (n=10)	4.7±1.36	3.6±1.01	1.1 (23.4)	2.05*
Hand weeding(n=09)	3.53±0.63	3.07±0.65	0.46 (13.03)	<b>NS</b>
Earthing up (n=10)	4.6±1.2	3.09±0.98	1.51 (32.82)	3.14**
Manual fertilizer application (n=10)	4.7±1.02	3.6±0.99	1.1 (23.4)	2.44*
Sorting & cleaning (n=10)	3.5±0.52	2.6±0.69	0.9 (25.71)	3.29**

NS - Non significant, \*- significant at 5%, \*\*- significant at 1%, Figures in parenthesis indicates percentages

**Table 7. Time and work study of the selected activities in turmeric production system**

Name of the activity	Existing method (Mean ± SD)	Improved method (Mean ± SD)	Increase/ decrease improved over existing (%)	't' values
Planting of turmeric rhizomes by using Ukari [area : m/hr]	104.71±30.17	132.32±36.3	27.61 (26.36)	1.85*
Planting of turmeric rhizomes by using finger guards [area : m/hr]	101.26±27.32	114.11±29.37	12.85 (12.69)	NS
Hand weeding [area : m/hr]	10.51±3.2	9.6±2.9	0.91 (8.65)	NS
Manual fertilizer application [area : m/hr]	337.53±219.68	415.01±258.83	77.48 (22.95)	NS
Earthing up [area : m/hr]	68.91± 5.95	83.78±8.64	14.87 (21.57)	4.43**
Sorting and Cleaning(kg/hr)	73.86 ± 16.4	88.91 ± 18.69	15.05 (20.37)	1.91*
Turning of turmeric fingers while drying (min/qt)	18.73±2.23	16.8±1.76	1.93 (10.3)	2.15*



Plate 1. Digging tool



Plate 2. Finger Guards for digging soil while planting turmeric rhizomes



Plate 3. Earthing up tool



Plate 4. Sulbha bag while fertilizer application with plough



Plate 5. New Khurpi for Weeding



Plate 6. Wooden rake for Turning of turmeric fingers while drying



Plate 7. Mitten for cleaning & sorting

#### 4. CONCLUSION

The ergonomic assessment revealed that the physiological cost of selected activities performed by farm women in existing and improved method was the same but the perception of workload was found to be reduced with improved tools. All the developed technologies used by farm women in the turmeric production system for planting, earthing up, fertilizer application and drying were successful in increasing pace of work. In all these activities, the output was significantly increased by 10-26 per cent.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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