PERFORMANCE OF TOOLS IN TREE FELLING AND CONVERSION IN CHANGA MANGA FOREST PLANTATION

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Abstract

The performance of conventional and improved hand tools in tree felling and conversion was tested in Changa Manga Plantation on the basis of labour productivity and workload. The results of time and heart rate studies showed that the improved tools demanded 12.4 minutes less of work time per cubic meter of timber and firewood converted. The technical labour productivity for work with improved tools was also higher by about 24% and this increase was highly significant. Improved tools also reduced the physical workload on the workers highly significantly as shown by their lower average total pulse by 9 beats/min. These results indicate that introduction of improved tools and vocational training of forest workers are very essential for higher labour productivity and improvement of socio-economic conditions of forest workers in Pakistan.

Introduction

The present state of forest work in almost all developing countries is very poor. The workers work under very difficult conditions on a very low wage rate, with primitive tools and without vocational training, resulting into a low labour productivity and poor income. There is an urgent need for research for the improvement of work and the workers a lot in these countries. Comparison of work means, methods and ergonomic research are essential for optimization of "Man-Task System" and to improve the socio-economic condition of forest workers by way of reduced physical workload and increased work productivity.

A study was undertaken in the irrigated planation of Changa Manga in winter of 1984-85 to compare the efficiency of conventional tools and improved tools in tree felling and conversion for the selection of better tools and methods. The criteria were the physical workload and technical labour productivity in this study.

MATERIAL AND METHODS

Material

The performance of conventional tools (axes and crosscut saws, peg-tooth) and improved tools (bow saws and crosscut saws, raker-tooth) in tree felling and conversion was compared on the basis of technical labour productivity and physical workload on the workers in Changa Manga Plantation in winters of 1984-85. The study was conducted in compartment No. 157

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and 12. The crop consisted of a mixture of mature trees of mulberry (*Morus alba*) and shisham (*Dalbergia sissoo*) ready for main felling. The workers first worked with conventional tools and methods followed by improved tools. Two week training in the use of new tools and proper wor echniques was also imparted to them. With each tool system the workers worked in work party sizes of 2, 3 and 4 persons and in all felled and converted 351 trees of mulberry and shisham with an average DBH of 27 cm (range 13—72 cm). Each felled tree was measured for its DBH, total length and number of branches of first order which were thicker than 5 cm.

Methods

Time Studies: Time needed to fell and convert a tree and with respect to different work elements was recorded by the help of multimoment time study techniques with an observation interval of 1 minute. A work cycle (time to fell and convert a tree) consisted of 9 work elements e.g., personal delays, operational delays, walk to tree, felling, hang-up, debranching, firewood conversion, measuring and crosscutting. Time taken for preparation of work was recorded at the start and end of work only.

Recording of work results: at the end of each day the number and volume of timber pieces was computed by Huber's formula and weight of firewood with the help of spring balance was recorded for each tree felled and converted. Weight of firewood was converted to cubic meters by using the green density of firewood by the Mercury Displacement Method (KOLLMANN and COTE, 1968).

Measurement of Resting Heart Rate (Resting Pulse): Every day before the start of work the resting heart rate (resting pulse) of each worker was recorded in the state of rest for 10—15 minutes at radial artery, manually.

Measurement of Heart Rate (total pulse) during work: Observations on heart rate (total pulse) as a measure of physical workload on the workers were recorded manually with an observation interval of 3 minutes and with respect to different work elements. At the observation point the time of 11 pulse beats was recorded with the help of a stop-watch by placing the fingers of hand either on carotid artery near Adam's apple (LOON, 1984, ANDERSON, 1971) or radial artery in the wrist (GRANDJEAN, 1981) of the workers. Total pulse as number of pulse beats/min was calculated by keeping 600 as numerator and time of 11 pulse beats in seconds as denominator.

The difference between average resting heart rate of a worker and average total pulse during work gave the average working pulse.

ANALYSIS OF DATA

Organization of Data: The information recorded during field experiment were classified into two data sets:

— data set on time and technical labour productivity

— data set on physical workload (Heart rate).

Each data set was further divided into sub-sets on the basis of tools.

Statistical Procedures: The statistical analysis of data consisted of the following:

— calculation of basic statistics,
— testing of difference between the means of data sub-sets and
— testing of relationship within the data sub-sets.

The significance of difference between the means of corresponding variables from two data sub-sets, e.g., between the mean technical labour productivity with conventional and improved tools was tested with "two-sample t-test".

To study the interdependence of variables, the random relationship between the dependent variable of work time (Y-variable) and one or more independent variables (tree parameters, X-variables) was tested with stepwise multiple linear regression analysis.

All statistical procedures were carried out with the help of a desk computor HP 9817 A series 200, with a tolerance and confidence limits of 0.0001 and 95%, respectively.

Results and Discussion

The results reported below are for an average work party size of 3 persons.

TIME STUDIES

As shown in Table 1, the average corrected total and effective work time/m^3 of tree volume for felling and conversion of mulberry and shisham trees, with conventional and improved tools were 72. 4 and 60.0 minutes, respectively.

Table 1. Corrected values of average total and effective work time/m^3 of tree volume in felling and conversion of mulberry and shisham trees with conventional and improved tools.

Times	min/m^3		Decrease for improved tools	
	Conventional tools	Improved tools	min	%
Total work time	72.4	60.0	12.4	17
Effective work time	49.5	42.8	6.7	14

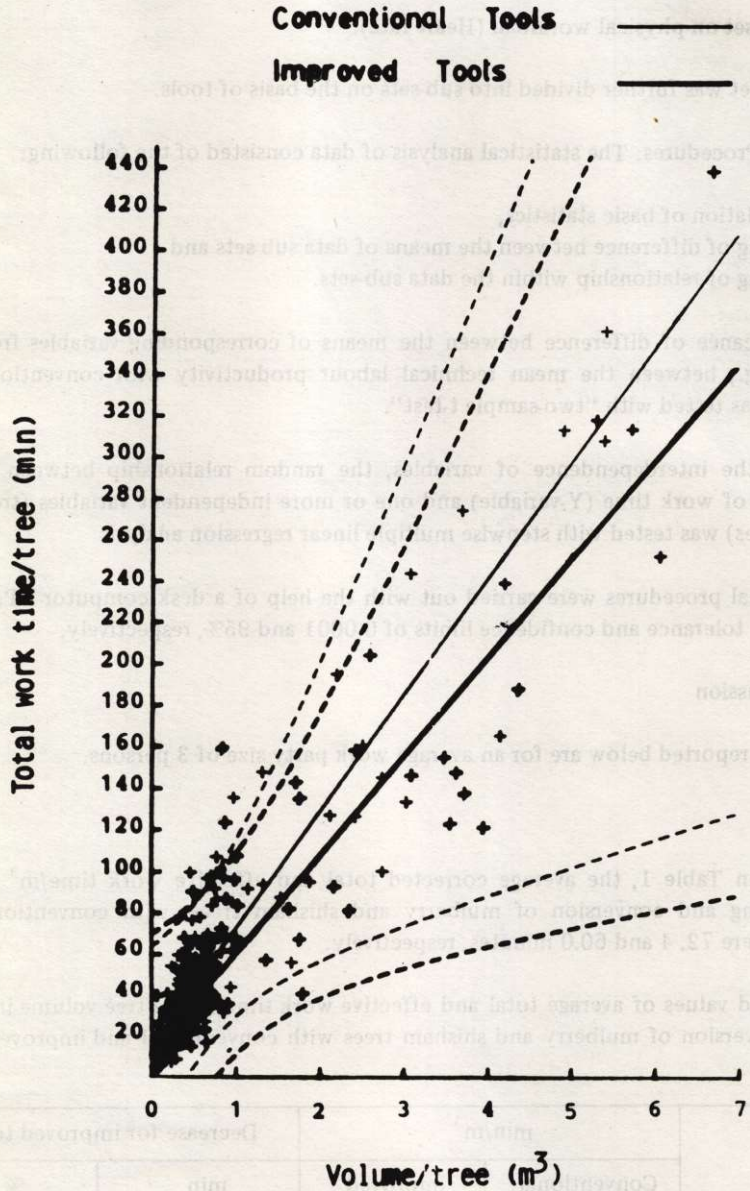

Fig. 1: Relationship between total work time/tree and tree volume in felling and conversion of trees with conventional and improved hand tools

Improved tools were faster in work and demanded 12.4 min (17%) less of total work time/m^3 of tree volume as compared to conventional tools. Similarly effective work time was also reduced from 49.5 min/m^3 to 42.8 min/m^3 of tree volume with improved tools which gave an effective work time saving of 6.7 min/m^3 (14%) of tree volume in comparison to conventional tools.

The resuction in the work times with improved tools was non-significant as tested statistically (Fig. 1) because of overlap of confidence limits being more than 2/3.

The results of multiple linear regression analysis (Table 2) showed that the total work time/tree was very strongly and highly significantly related to the tree parameters like DBH, number of branches and total tree volume in case of conventional tools and to only number of branches and tree volume in case of improved tools. Work time demand with improved tools remained independent of DBH of the trees. The product of regression coefficient (b_i) and standard deviation (s_i) showed that among the different tree parameters, the total tree volume was the strongest determinant of work time per tree followed by number of branches and DBH in case of conventional tools and the number of branches only for improved tools.

Table 2. Result of multiple regression analysis between total work time (dependent variable) and tree parameters (independent variables) in felling and conversion of mulberry and shisham trees with conventional and improved tools.

Tools	Dependent variable	Independent	$b_i x s_i$	R^2	F value
Conventional tools	Total work time	DBH	9.48		
		Branches	5.29	0.88	471.57***
		Tree volume	38.06		
Improved tools	Total work time	Branches	5.38		
				0.85	418.40***
		Tree volume	52.63		

*** Significant at 99% level

TECHNICAL LABOUR PRODUCTIVITY

As shown in Table 3, the average technical labour productivity with respect to total work time remained 0.25 and 0.31 m^3 (timber and firewood)/man hour with conventional and improved tools, respectively. The improved tools caused a highly significant increase of 0.06 m^3/man hour (24%) in the technical labour productivity.

Table 3. Average technical labour productivity (m^3/man hour) in felling and conversion of mulberry and shisham trees with conventional and improved tools.

Productivity variables	m^3/man hour		Increase for improved tools	
	Conventional tools	Improved tools	m^3/man hour	%
Total volume/total work time	0.25	0.31	0.06	24***
Total volume/effective time	0.37	0.45	0.08	22***

*** Signifcant at 99% level

Similarly the average technical labour productivity for conventional and improved tools and with respect to effective work time was calculated as 0.37 and 0.45 m^3/man hour. The improved tools gave a higher technical labour productivity of 0.08 m^3/man hour (22%) in comparison to conventional tools and this increase was highly significant.

GURTAN (1964) reported a 33% increase in the technical labour productivity in the coniferous forests due to introduction of improved tools and training of forest workers. The higher increase in this case is mainly because of different workers, three species and work requirements.

Heart Rate (Physical Workload)

As shown in Table 4, the average total and working pulse of the workers for work with conventional tools remained 100 and 27 and with improved tools as 101 and 18 pulse beats/min, respectively. Improved tools caused a highly significant reduction in the physical workload as depicted by lower average total pulse and working pulse by 9 beats/min.

Table 4. Average total and working pulse of the workers druing felling and conversion of mulberry and shisham trees with conventional and improved tools.

Average heart rate parameters	Tools		Decrease in heart rate with improved tools
	Conventional	Improved	
Resting heart rate	83	83	0
Total pulse	110	101	9***
Working pulse	27	18	9***

*** Significant at 99% level

Similarly the average total pulse of the workers (Table 5 and Fig. 2) for work with improved tools remained lower to various extents in comparison to conventional tools for all the work elements. This change was very highly significant for felling, releasing of hang-ups, firewood conversion and crosscutting with a reduction in the average total pulse of the workers by 24, 23, 5 and 6 pulse beats/min, respectively. While in work delays and debranching a significant and non-significant reduction in the average total pulse by 2 and 4 pulse beats/min was recorded, respectively.

Table 5. Average total pulse of the workers with respect to different work elements in felling and conversion of mulberry and shisham trees with conventional and improved tools.

Work elements	Average total pulse		Decrease for improved tools
	Conventional tools	Improved tools	
Work delays	03	91	2*
Felling	132	108	24***
Hang-up	122	99	23***
Debranching	116	112	4
Firewood conversion	111	106	5***
Cross-cutting	113	107	6***

* Significant at 95% level
*** Significant at 99% level

The average total pulse in felling and releasing of hang-up with conventional tools and methods was 132 and 122, respectively and the workers worked well above the limit of sustained performance. With improved tools these operations were rendered very easy as depicted by the average total pulse of 108 and 99 beats/min, respectively. This means that improved tools were very effective in cutting down the peak loads on the workers.

HANSSON *et al.* (1966) in their studies on tools and ergonomics in Indian logging operations, reported an average total pulse of 126 beats/min in felling of trees. This figure is by 6 pulse beats/min lesser and 18 pulse beats/min higher than in felling of trees with conventional and improved tools, respectively. This difference can be due to different workers and tree species.

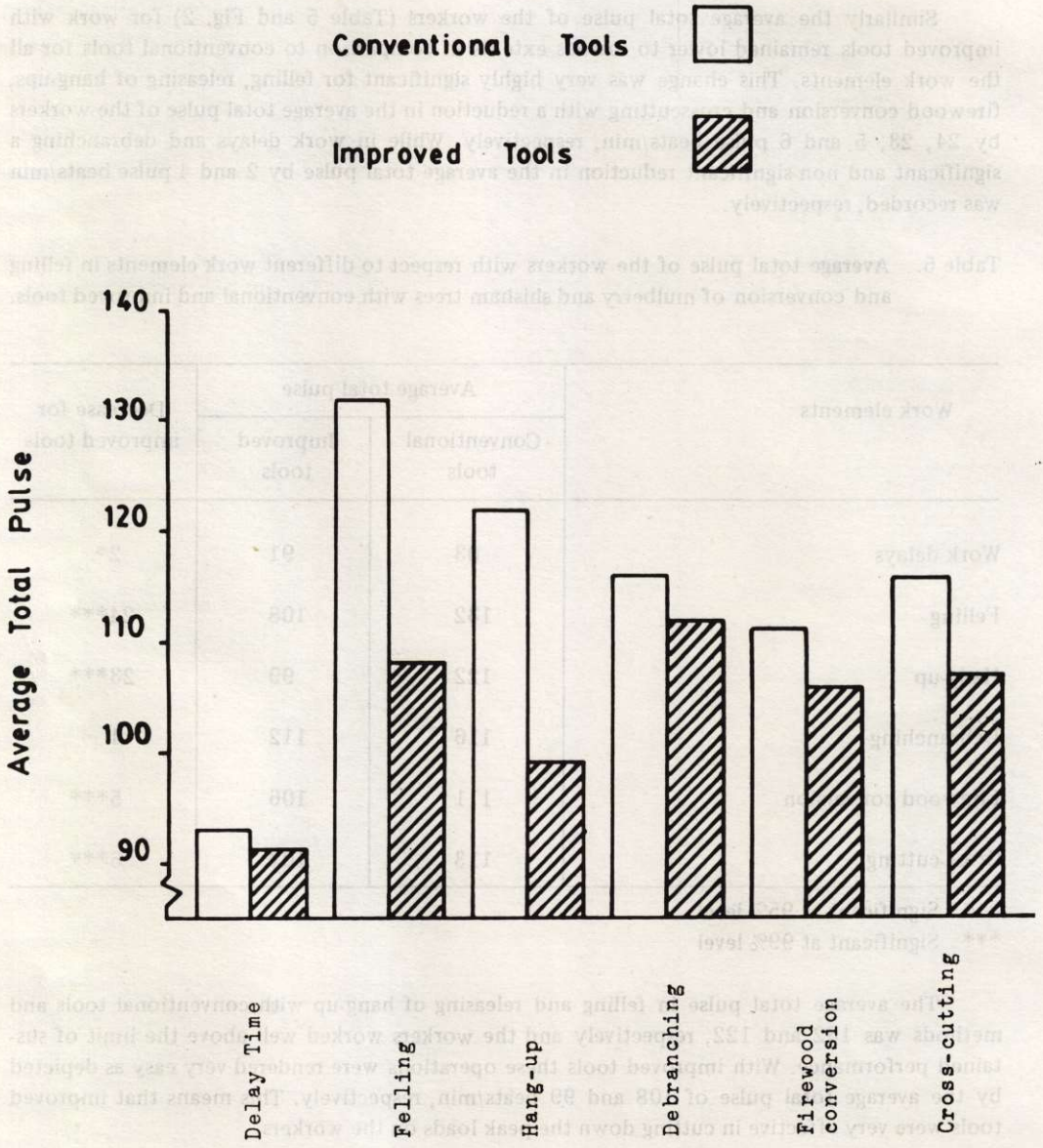

Fig. 2: Average total pulse of the workers in tree felling and conversion with conventional and improved tools.

Cost of work (Rs./m^3)

— Conventional tools:

Technical labour productivity with conventional tools	0.25 m^3 /man hour (timber + firewood)
*Cost of conventional tools/man hour	Rs. 6.03
Cost/m^3 of timber + firewood	$\frac{6.03}{0.25}$ = Rs. 24.12

— Improved tools:

Technical labour productivity with improved tools	0.31 m^3 /man labour (timber + firewood)
*Cost of improved tools/man hour	$\frac{\text{Rs. } 6.72}{0.31}$ = Rs. 21.67

Cost of improved tools with training of workers was less by Rs. 2.45/m^3 than conventional tools. Therefore, the improved tools and work techniques gave a cost saving of about 11% than work with conventional tools.

* (Capital + personal costs)

Conclusions

The results of the study revealed that improved hand tools with a very short training of workers, resulted into a highly significant increase in the technical labour productivity in tree felling and conversion alongwith a very highly significant reducation in the physical workload on the workers as well. Higher work performance at a lower physical cost is of great significance in the humanization of forest work and better socio-economic conditions of forest workers. Moreover, improved tools not only proved advantageous in material and human aspect of work, but remained by about 11% more economical in the cost of work/m^3 of timber and firewood converted. These results form the basis of the following conclusions:

1. Improved tools like bow saws and raker-tooth crosscut saws should be introduced in timber harvesting in Pakistan.

2. Vocational training programmes for the forest workers in proper work methods, use and maintenance of different tools and ergonomics should be initiated.

3. System of petty forest contractors should be abolished and the workers should directly be paid by the forest departments.

ACKNOWLEDGEMENT

The study is a part of a Ph. D Thesis which was completed under the guidance of Professor Dr. H. Loeffler, Institute of Work Science and Operational Methods in Forestry, Faculty of Forestry, University of Munich, Federal Republic of Germany. The author feels grateful to Professor Loeffler for his help in this work.

REFERENCES

1. Anderson, K.L.: Methods for measurement of maximal aerobic power. Methods in ergonomic research in forestry. IUFRO Seminar Silvifuturum, Hurdal, Norway, 1971.

2. Grandjean, E.: Fitting the task to the man. An ergonomic approach. Taylor and Francis Ltd., London, 1981.

3. Gurtan, H.: Die Arbeitsproduktivitat bei den Holzernte in der turkischen Forestwirtschaft. Inaugural-Dissertation zur Erlangung der Doktor wurde der Naturwissenschaflich—Mathematischen Faknltat der Albert-Ludwige-Universtitat Freiburg, 1964.

4. Hansson, T., A. Lindholm, H. Birath: Men and tools in Indian Logging Operations. A pilot study in ergonomics. Department of Operational Efficiency, Royal College of Forestry, Stockholm, Sweden, 1966.

5. Kollmann, F.F.P., W.A. Cote: Principles of Wood Science and Technology. Vol. I Solid Wood. Springer-Verlag, New York Inc., 1968.

6. Loon, van, J.H.: Work physiology in occupational practice. Training Course "Introduction to Ergonomics". PET, Wageningen, the Netherlands, 1984.