EFFECTS OF WORN HANDTOOLS ON WORKER PRODUCTIVIETY IN LABOUR-BASED ROADWORKS

IT Transport Ltd

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© Institute of Development Engineering, Loughborough University, Leicestershire, LE11 3TU

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TABLE OF CONTENTS

Preface - The MART Initiative

The Management of Appropriate Road Technology (MART) initiative aims to reduce the costs of constructing, rehabilitating and maintaining road infrastructure, and vehicle operations in economically emerging and developing countries (EDCs). It is based on a research project funded principally by the Department for International Development (DFID), formally the Overseas Development Administration (ODA), under its Technology Development and Research (TDR) provision. The initiative is led by the Construction Enterprise Unit of Loughborough University's Institute of Development Engineering, in association with two UK-based specialist consultants Intech Associates and I.T.Transport. The MART programme is currently implementing its initial 3 year programme.

The MART programme is concerned with supporting sustainable improvements in road construction and maintenance in developing countries. This implies the effective use of local resources, particularly human resources and readily available intermediate equipment (especially wheeled agricultural tractors and related ancillary equipment). To optimise the use of scarce financial resources, it also requires the effective mobilisation of the indigenous private sector (particularly small domestic construction enterprises), and the application of good management practices in both contracting and employing organisations.

The current phase of the MART programme will *inter alia* draw together existing expertise in labour - and intermediate equipment-based technology and the development of private construction enterprises to produce a series of guidelines on the four priority topics of:

- handtools;
- intermediate equipment;
- private sector development; and
- institution building.

The MART initiative is strongly research-based, and both the DFID and the MART partners see its main impact as providing analysis and codification to support practical project initiatives. Thus much of the output will be in the form of journal papers and other formal publications suitable as reference material and providing an independent and reliable record of the advancing state of the art.

MART welcomes dialogue with engineers, equipment designers and manufacturers regarding designs, products or experience of intermediate equipment with the objective of the promotion of a sustainable road sector technology and management approach for EDCs.

This document is an output from a project funded by the UK Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of the DFID.

1. INTRODUCTION

This study has been planned as part of the MART component on handtools with the aim of obtaining information on the impact of handtool quality on the productivity of workers on labour-based road works.

Although the quality of handtools is generally considered by road engineers to be very important to the productivity of labour-based methods, there is very little reported evidence to quantify this and very limited recorded studies under actual road-working conditions. Experience indicates that one of the primary reasons for the large variation of quality of handtools used in road works is the lack of appreciation by procurement personnel of the benefits of good quality tools. Measured data on benefits, particularly economic benefits, could therefore be very influential in promoting improved procurement procedures leading to more widespread use of good quality tools.

The study was organised as the major project of a student, Simon Ramm, studying the MSc course on Engineering for Development at Southampton University. It was planned that Simon would spend six weeks in Ghana in July/August 1996 working with a local contractor, Ing Edward Opoku-Mensah, Chairman of LB Contractors Association. Mr Opoku-Mensah very generously agreed to provide the facilities for Simon to carry out studies on the effect of handtool quality on the productivity of workers on sites where rehabilitation work was being carried out. Unfortunately due to health problems Simon was only able to complete one week of the study but during this period very useful results were obtained on the effect of tool quality on the productivity of ditching and sloping operations.

The tools used in these activities were round-nosed shovels and pickaxes. The factor investigated was the effect of wear of the tools on worker productivity. Measurements were made of two groups of workers, one using new tools and the other worn tools, over 3 days of ditching and then 3 days of sloping.

Section 2 of the report describes the methodology adopted for the tests to minimise the effects of variables other than tool wear, and Section 3 the organisation of the tests on site. Details of the tools are given in Section 4, whilst Section 5 describes the testing procedure and information recorded. The results of the study are presented in Section 6 and discussed in Section 7.

Acknowledgement

This report is based on a report submitted by Simon Ramm. I T Transport is very grateful to Edward Opoku-Mensah for providing the opportunity and facilities for Simon to carry out the study and for his advice, support and assistance in carrying our the work.

2. METHODOLOGY

The first step of the study was to meet the workers who were to be involved. It was important to make them feel at ease so that they worked as normally as possible. It was explained to them that it was not themselves under investigation, but rather the tools they were using. There were 14 workers on site.

It is important to have a consistent team of workers when the numbers are small (12 workers were used), so they must all be available during the planned experiments.

Because of the small number of workers it was useful to find out a little about each of their backgrounds, for instance, their name, their age, their experience with the type of road building to be done (ditching, sloping) and also whether they were local or living in the work camp in the next village.

Of the 14 workers on site, 12 were living in the work camp and 2 were local. Since local workers generally have a greater incentive to complete their work tasks as quickly as possible in order to get home early to work in their fields, the 2 local workers were not included in the tests so that the 12 workers used theoretically had a similar level of motivation. However, it is impossible to completely eliminate worker attitudes as a variable.

The team was split into 2 halves so new and worn tools could be compared under similar conditions of:

- similar activity
- similar location/soil type
- similar weather
- similar levels of motivation/tiredness.

i.e. by using both new and worn tools on the same day. If all 12 workers had used good tools one day then bad tools the next, conditions would not have been so similar, it would have been a less valid comparison.

The two groups were chosen so that the sum total of experience in each was roughly the same. It was decided that experience was a better criterion than age for working performance (in any case all the men were under 30).

Splitting the team into 2 halves also meant that less new tools were needed, these were purchased specifically for the trials.

3. PREPARATIONS ON SITE

The site was divided into sections of 20 metres which was the daily 'task' for ditching. Poles were used to mark each section.

On the first day ditching was carried out on both sides of the road. The workers were arranged alternately with new and worn tools to ensure the soil conditions were as similar as possible for each tool group.

Before starting, it was noticed that some sections would have more interference from tree roots than others. This might have made some sections unfairly difficult. Because of this, as many roots as possible were chopped out before work began, and during work there was a separate team of men with axes who could be called upon to remove roots by the workers involved in the study. Other than that, each section was very similar in terms of soil type etc.

Once again workers were asked to work normally. On this site (and most others), the workers perform a task in the morning - once this task is checked and approved the worker can stop, but the transport to the camp came at the same time every day (3pm ish). However, the main motivation was to work quickly but comfortably, so that the worker could get as much rest as possible before the next day's activity. One man asked if he could help his friends if he finished early, but this was not allowed during the experiments.

4. TOOLS

Six new shovels and six new pick-axes were purchased for the study. Each was labelled with a number using red paint on the handle.

The worn tools were modified to give them similar operating characteristics by fitting new handles to both the worn shovels and pick-axes. Worn tools were used which were significantly worse than the new ones, yet still usable and likely to be used by the average contractor[1]. Each of these tools was also labelled with a code number on the handle.

The worn and new tools came from the same manufacturer (similar metal, quality, shape etc.). There were not enough types of tools locally available to compare different brands.

All the tools were then lined up on the ground, and a photograph taken (see Figure 1). The dimensions of the old tools were measured (width, length, handle length etc. - see results), and each one given a score out of 5 depending on quality. The better of the worn tools were given to the less experienced workers. It was considered that this would reduce the scatter in the results and give a better indication of the average effect of tools wear on worker productivity. Details of individual tools and their allocation to workers in each group are given in Annex 3.

Each worker was then allocated tools for the first day's experiment, one shovel and one pick-axe/mattock each. Six workers had a new shovel and new pick-axe and the other six a pair of worn tools.

5. OBSERVATIONS

Considerable emphasis was placed on observations during the experiment, to compensate for the limited number of workers. This was possible because the task took about 3 hours to complete. A stopwatch was used to measure the time needed by each worker. All workers started at the same time.

Other factors noted were:

- the weather was monitored so that its effects could be taken into account - rain made the soil much heavier to dig and remove, sunshine made the work more tiring.

- special problems were monitored and taken into account - for example a tool breaking, a handle coming off, unexpected ground conditions.

- times were noted when a worker finished his task - if it was approved by the foreman, that time was recorded. If the foreman decided the work was not acceptable the extra time needed to improve poor sections was added.

Standard result sheets were prepared to streamline the recording of observations, this proved very useful in being able to record clear and accurate observations and results for each worker.

About half way through the task and also when the work was finished each worker was asked the following questions:

· Name?
· How long do you think you need to finish? (Useful for planning and anticipating

[1] The average period of use of the worn tools was about 3 months. It is estimated that the tools have an average life of 3.5 to 4 months. A note on the degree of wear of the tools in included 6.2.

recording of results);
- Have you had any problems with your tools?
- Have you had any breaks?
- Have you lost any time due to tool problems (breakages)? If so how much?
- Have you had to spend any time cutting out roots? How long?
- Are you - not tired
  - a little bit tired
  - tired
  - very tired
- Do you have any aches, pains or injuries?

The next day the ditching was continued, but the group who had used the worn tools were given the new ones and vice-versa.

Unfortunately this road contract was almost complete and there were only 3 days ditching left to do when the tests were started so that results could only be obtained for the 3 days.

However, 3 days results were also obtained for sloping in exactly the same way as for ditching.

At the end of the experiments, a group discussion was held and the following questions were put to the workers:

- is the task too small/big with the new/worn tools?
- what do you think of the good/worn tools - how do they compare?
- what motivates you to work faster?

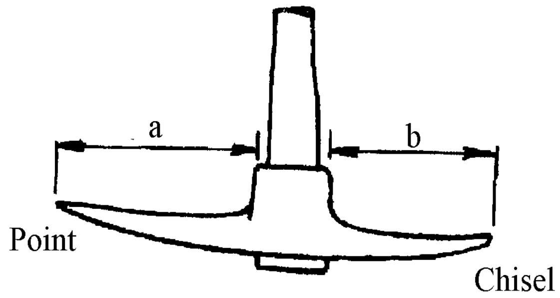
6. RESULTS

6.1 Details of workers

Workers Initials	Age	Relevant experience or roadwork in years
RF	22	2
YD	21	1½
JA	24	3
AB	22	1½
FA	30	2½
JN	25	¼
YM	28	1½
BA	30	2
SM	22	1½
YA	26	1½
IQ	20	¼
KD	20	½

6.2 Details of tools

Pick-axe



Shovel

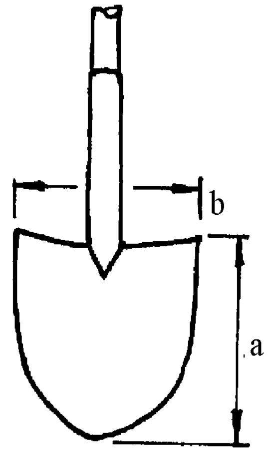


Table: Average Dimensions and Wear of Tools

Condition of tool	Pick-axe		Shovel	
	a (cm)	**b** (cm)	**a** (cm)	**b** (cm)
1. **NEW**	30	25	29	23
2. **WORN**	15	14	19	23
Average wear (%)	50	44	34	0

Note: tools are considered fully worn[2] when they have reached the following level of wear:

Pick-axes - 55% ie reduced to 45% of original size

Shovels - 40% ie reduced to 60% of original size

The average wear of the tools used in the tests is therefore 80 to 90% of being fully worn out.

6.3 Measurements and observations

The results sheets for the test programme giving measurements of the times taken by each worker for the daily tasks and other recorded observations are contained in Annex 1 and 2 of the report as follows:-

[2] Correspondence from Ing. Edward Opoku-Mensah

FIGURE 1 Comparison of new and worn tools used in this study

FIGURE 2 Comparison of "worst" tools with new tools

FIGURE 3 Work in progress

Annex 1 : Day 1, 2 and 3 of ditching activity

Annex 2 : Day 1, 2 and 3 of sloping activity

The results for ditching are summarised in Table 1 and for sloping in Table 2.

6.4 Qualitative results

The following comments were made by workers in the group discussion following the test programme:

- workers felt the task was "a bit on the high side".
- old tools:
  - make the workers tire more quickly
  - cause them muscle/joint pains plus blisters and broken skin
  - make task harder
  - increase the time needed to complete the task
  - make them more tired at the end of the task
- workers are motivated by having more time off before the next day's task begins.
- another form of motivation is competition - the first one to finish is considered the best
- it was noted that there were very few tool breakages in the three days of ditching/sloping (less than 5 in total). Therefore it would take a very long time to be able to compare performance in terms of reliability of tools. Time wastage was negligible.
- workers did not take long breaks - 15 or 30 minutes rest for water, toilet or food throughout the whole task was normal.
- it was mentioned that when new **hoes** were used they were initially less productive because people were nervous of how sharp they were (injury risk).

7. DISCUSSION OF RESULTS

The results of productivity tests are summarised in Table 1 for the ditching activity and Table 2 for the sloping activity. Although only 3 days of testing could be carried out for each activity, splitting the team into 2 groups gives 3 sets of results for both new and worn tools for each activity and enables comparisons to be made between the two groups (one with new, one with worn tools) on each day and also for the same group using new or worn tools on different days. The average results are summarised as follows:

Ditching:

Group 1: average improvement in time needed to complete task (ie time saved) by using *new* tools - 58.5 minutes.

TABLE 1: Results for standard ditching task using New and Worn Tools

Time taken for task (hrs/mins)				
Group 1 Worker (Experience in yrs)	**Day 1** **Worn**	**Day 2** **New**	**Day 3** **Worn**	
FA (2½)	3.05	2.48	4.23	
BA (2)	4.07	3.50	5.30	
SM (1½)	4.30	3.08	5.15	
YA (1½)	3.33	4.25	5.35	
IQ (¼)	3.59	4.25	5.50	
KD (½)	5.15	3.37	5.05	
Average	**4.05**	**3.42**	**5.16**	**Average difference between Worn and New, Group 1=58.6 mins**
Standard Deviation	0.41	0.36	0.28	
Group 2	**New**	**Worn**	**New**	
RF (2)	2.30	4.10	4.02	
YD (1½)	2.44	4.30	4.15	
JA (3)	2.26	3.33	4.00	
AB (1½)	2.43	3.40	3.50	
JN (1½)	4.45	5.15	6.10	
YM (1½)	2.44	4.35	4.22	
Average	**2.59**	**4.17**	**4.26**	**Average difference between Worn and New, Group 2 = 34.5 mins**
Standard Deviation	0.48	0.35	0.41	
Difference between Worn and New on each day	**1.06**	**0.35**	**0.50**	**Average 50 mins**

TABLE 2: Results for standard sloping activity using New and Worn tools

Time taken for task (hrs/mins)				
Group 1 Worker (Experience in yrs)	**Day 1** **NEW**	**Day 2** **WORN**	**Day 3** **NEW**	
FA (2½)	2.00[1]	3.00	2.17	
BA(2)	2.00	3.05	3.30	
SM (1½)	3.20	3.10	4.10	
YA (1½)	3.05[1]	3.00	2.52	
IQ (¼)	3.00	3.05	4.25[2]	
KD (½)	4.30[2]	3.45	3.25	
Average	**2.59**	**3.11**	**3.27**	**Average difference between Worn and New, Group 1 = -2 minutes**
Standard deviation	0.51	0.16	0.43	
Group 2	**WORN**	**NEW**	**WORN**	
RF (2)	2.30[1]	2.15[2]	2.00	
YD (1½)	2.30[1]	2.00	3.05	
JA (3)	2.45	2.35	2.55	
AB (1½)	3.10	2.15	3.35	
JN (¼)	4.20	3.20	4.20	
YM (1½)	4.00	3.05	3.15	
Average	**3.13**	**2.35**	**3.12**	**Average difference between Worn and New, Group 2 = 37 minutes**
Standard deviation	0.43	0.29	0.42	
Difference between Worn and New on each day	**0.14**	**0.36**	**-0.15**	**Average 12 minutes**

Notes:
1. Low-lying area with shallow drains
2. Hard surface or rocky

Group 2: average improvement in time needed to complete task by using *new* tools - 34.5 minutes.

Group 1 & 2: average improvement of group using *new* tools over group using *worn* tools over 3 days - 50 minutes.

Sloping:

Group 1: average improvement in time needed to complete task by using *new* tools - 2 minutes (slightly more time due to change in soil conditions)

Group 2: average improvement in time needed to complete task by using *new* tools - 37 minutes.

Group 1 & 2: average improvement of group using *new* tools over group using *worn* tools - 12 minutes.

The results for each group are the average of six workers so that for each activity there are 18 results for new tools and 18 for worn tools, making the results statistically meaningful. The interchanging of tools between the workers and the alternate positioning of workers with new and worn tools has accounted for the effects of worker skill/motivation and soil conditions so it is considered that the results give a reliable measure of the deterioration in worker productivity caused by worn tools. The results show up the following factors:

- The wear of the tools has a much greater impact on productivity of workers on the ditching activity than on the sloping activity. Although the volume of material removed should be roughly the same, ditching involves more breaking of virgin ground and probably throwing removed material over a greater distance. The overall average results clearly show that ditching is a harder task:

Task	Average task time with *worn* tools (hrs/mins)	Average task time with *new* tools (hrs/mins)
Ditching	4.33	3.42
Sloping	3.12	3.00

Most of the comments on problems of *worn* tools relate to the extra effort needed due to the bluntness of the tool so it seems likely that it is the cutting and digging into the soil where the main loss in productivity occurs as tools become worn rather than in moving the soil. However, the average reduction in area of the shovel blades of around 34% suggests that there must also be some loss in efficiency in moving the soil.

The state of the soil has a significant effect on the time taken for the ditching operation as shown by the daily averages:

	DAY 1	DAY 2	DAY 3
Average time with *new* tools	2h 59	3h 42	4h 26
Average time with *worn* tools	4h 05	4h 17	5h 16

The time to complete the ditching task increased by more than an hour over the three-day period. It is not apparent how these results relate to the shortest and longest times that might be experienced in completing the task. Because of the increased difficulty of the task on Days 2 and 3, some workers actually took longer to complete the task with *new* tools compared to using *worn* tools on the previous day. This shows up in the average time for *new* tools on Day 3 being higher than that for *worn* tools on Day 2. However, on each day the average time for the group using *new* tools was consistently lower than for the group using *worn* tools.

· There is no correlation between the quality of individual *worn* tools (Annex 3) and the time taken for the task. It is clear that the experience, capability and motivation of workers are overiding factors, but each worker generally achieves a higher productivity with a better quality tool.

· In the tests carried out, the use of *worn* tools reduced the productivity of workers on the ditching operation by 20 to 25% but on the sloping operation by only about 5%. However, in the fixed task system used it appears that this has no effect on the cost of the work. The benefits of using better quality tools appear to be only to the workers themselves in enabling them to complete the given task in less time, with less effort and with fewer aches and pains. Presumably the given task is based on the work that can be completed in a reasonable time using tools of a given quality level - eg “average” quality (half-worn) or “poor” quality (almost fully worn to the stage where they need to be replaced). If tools are changed more frequently to increase the general quality level then it may be possible to increase the daily task to take advantage of the increased productivity. The economics of this would need to be evaluated by the contractor. For example, in simplistic terms:

If tools are changed every 3 months instead of every 4 months, the cost is one extra tool per worker per year. If this allows the task rate to be increased by 10%, say from 20 to 22m per day then the extra income to the contractor for 200 working days per year is for an extra 400 m of work per worker. It is possible that this might also allow an increase in the daily payment for the task as an incentive to the workers.

The use of better quality tools will always be of advantage to the workers in reducing the time and effort needed to carry out a task. Some of this advantage will flow onto the contractor (or government or local authority) in terms of a more productive and better motivated workforce. However, the economic benefits may depend on a range of factors, - terms of the contract; scope for increasing daily tasks; availability of additional work to make up for increased productivity; agreements with and the attitudes of workers etc .... - and are more difficult to predict.

· In the case of the activities carried out in these tests, ditching and sloping, the main complaint regarding the *worn* tools was bluntness. It is possible that this could be partly overcome by regular maintenance to sharpen the tools but this would only be effective if the original tool material was properly hardened to sustain the cutting edges.

3. CONCLUSIONS

- The use of worn tools increased the average time needed for the ditching task by 50 minutes (22%) compared with using new tools, but only by 12 minutes (6%) for the sloping task. It appears that the difference in impact for the two tasks was due to the different nature of the work. The main problem of the worn tools was reported by the workers as bluntness resulting in more time and effort to cut and break up the virgin surface. There was more of this type of work in the ditching operation.

- The worn tools were still well within the limit of what would be used by contractors before being discarded and replaced so that tools nearing the end of their life would increase the times needed for the tasks by greater amounts than those recorded above.

- In the fixed task scheme of operation (workers complete a fixed task each day) it seems that the main advantage in using better quality tools is for the workers themselves in reducing the time, effort and physical impact of carrying out the task. Although the employer may benefit from a more productive and better motivated workforce it seems that daily task rates would need to be increased to yield economic benefits. In this case the cost of replacing tools more frequently would need to be more than offset by the increased income from completing more work per day. Benefits may be greater for schemes where workers are on an hourly rate or on an unrestricted piece-work rate (completing as much as they can in a day).

  In piece-work or task-work schemes the economic benefits depend upon there being additional work available to make up for increases in productivity.

9. RECOMMENDATIONS FOR FURTHER TESTING

Review of existing information

Three main factors define the quality of handtools and influence the productivity of workers using the tools:

1. Ergonomic efficiency - this relates to the ease and efficiency of use of the tool. The main parameters involved are shape, size, finish and weight of the tool.

2. Strength of the tool - whether the tool will stand up to its intended use without breaking, bending or being permanently distorted. The parameters are shape, size, material and heat treatment.

3. Wear and durability - the effect of wear of the working edges or surfaces on productivity and the rate at which the tool wears out.

The first two factors have been investigated for hoes, shovels and pick-axes in extensive tests carried out by de Veen and others in Kenya[3], in which construction quality tools were compared with farm quality tools.

The shapes and sizes of the two sets of tools (construction and farm) were broadly similar and little difference was found in the ergonomic efficiency of the tools. The only significant difference recorded was that workers achieved a 12% higher productivity with the construction type hoes, possibly because they were 25% lighter than the farm type.

However, significant differences were found in the strength of the two types, the farm type experiencing far more failures, particularly of handles, during the tests. Tool failures reduce worker productivity through the time lost in repairing or replacing the tool and possibly also by causing workers to work at a lower rate to reduce the risk of damaging their tools. Neither of these effects were recorded separately during the test. The former, loss of time, will depend very much on individual site conditions and organisation and it is probably not meaningful to quantify typical losses. The latter effect would show up on the overall differences in productivity of the tools and would be difficult to isolate. It may have contributed to the 12% difference in productivity of the two types of hoes but did not appear to affect the productivity of use of the shovels and pick-axes.

The tests were carried out over a period of 36 days, although individual tools were used on average 20 to 25 days. Average productivities were measured and there is no record of whether any trends were noted of productivity decreasing (task times increasing) over the test period as tools became worn. The average wear of the tools over the test was about 10% of the working length of the blade. It might be expected that some trend could have shown up with the more badly worn tools.

As far as is know, the results from the tests described in this report are the first to quantify the effect of

[3] J de Veen, in collaboration with J Boardman and J Capt: *Productivity of Durability of Traditonal* and *Improved Hand Tools for Civil Construction;* ILO/FAO, December 1981

tool wear on worker productivity. The results suggest that wear damage may have a more significant impact on productivity of tools used in earthworks than the other factors. This is backed up by evidence from sites where it is common to see workers struggling with badly worn and damaged tools.

Wear can make work harder and reduce worker productivity in a number of ways:

- bluntness and deformation of cutting edges reduce the efficiency of the tool - this is particularly important for hoes and pick-axes;

- the working area is reduced so that less work is done per working stroke - for example less material is moved or loaded per scoop of a shovel;

- the weight of the tool head (blade) is reduced so that the effectiveness of impact type tools (hoes, pick-axes etc...) is decreased.

Although the results show that badly worn tools can cause a substantial drop in productivity in excavation work, it is not clear whether this occurs gradually with increase in wear and what the benefits would be of changing tools more frequently. Further tests are needed using partly worn tools.

Priorities for further testing

An analysis of a number of LB projects in Ghana, Lesotho and the Philippines shows the following typical breakdown of LB costs to activities:

	Activity	Tools used	% labour cost	% overall cost
1	Cleaning and grubbing	bush knives, axes, pick-axes	5	1 to 2
2	Earthworks:		50 total	20 - 25
	· excavation	hoes, pick-axes, mattocks	25 to 30	
	· excavation/loading of fill	shovels	5	
	· haulage of fill	wheelbarrows	5	
	· spreading/formation	shovels, hoes, rakes, spreaders	10 to 15	
3	Excavation of rock	Crow-bars, pick-axes, sledgehammers	Up to 12	Up to 5
4	Gravelling:		30 total	12
	· excavation/loading	pick-axe, hoe, shovel	22.5	
	· spreading	rakes, spreader	7.5	

Based on contributions to overall costs, the priority for investigating the effect of handtool quality on worker productivity should be:

1. Excavation, movement and loading of soil - tools: hoes, pick-axes/mattocks and shovels

2. Excavation and loading of gravel - tools: hoes, pick-axes/mattocks and shovels

3. Spreading of soil and gravel - tools: rakes and spreaders

4. Excavation of rock - tools: pick-axes, sledge-hammers, crowbars

5. Haulage by wheelbarrow

For the most extensively used tools - hoes, pick-axes/mattocks and shovels - the review of existing information indicates that the priority should be an investigation on the effect of wear of the tools. Further tests are needed to substantiate the results already obtained and also tests of partly worn tools (say 30 to 50% of fully worn) to investigate the effect of changing tools more frequently.

For shovels, it is also recommended that handle length should be investigated since ergonomic studies indicate that long-handled shovels are more efficient for throwing and loading, and because they require less stooping and bending they cause less strain and muscle fatigue of the lower back.

For rakes and spreaders which are less standardised, the efficiency of different types/designs should be investigated as well as the effects of wear.

In addition to short term testing to investigate the effect of wear it would be useful to monitor the performance of tools over longer periods of time to build up a data base on different brands, particularly regarding strength, failure rates, time lost due to repair or replacement, and durability.

10. RECOMMENDED PROCEDURES FOR TESTING[4]

The simplest and most effective procedure is to compare the average times of groups of workers to complete a given task using the tools to be investigated.

To obtain reliable results it is recommended that a minimum group size of 8 workers is used, that each group should repeat the task at least 3 times with the same set of tools, and that each set of tools should be alternated between groups.

For ease of supervision and recording it is likely that only two sets of tools can be conveniently compared at one time using two groups of workers.

For example if it is required to compare three sets of tools, **N** ew, **P**art-worn and **W**orn the tests could be organised as follows using two groups of workers **A** and **B:**

Day	1	2	3	4	5	6	7	8
Group A	N	P	N	W	N	P	N	W
Group B	P	N	W	N	P	N	W	N

This is the minimum recommended level of comparison with 8 workers in each group. It would be preferable to have more than 8 per group and to at least include a further cycle of the above tests (4 days) and a set of tests (4 days) to compare P directly with W.

Since test conditions may vary daily, the two sets of tools need to be compared on a day to day basis and an overall average taken over a number of days. The reliability of the comparison will obviously increase with more days of testing.

The conditions for each set of tools that are being compared need to be as identical as possible and the effects of other factors balanced out. The following procedures are recommended:

Workers:

1. the two groups of workers should be balanced as closely as possible in skill and experience so that the group average time to complete a task with identical tools and under similar conditions is roughly the same;

2. the motivational level for the two groups should also be balanced as well as possible - for example the same number of local workers in each group who have the incentive to finish early in order to work on their household plots;

3. the tests should be carried out in as near to a normal working environment as possible with the minimum interference from the test procedures. It should be made quite clear to the workers that it is the tools that are being investigated and that they should work normally. The new tools themselves may provide an extra incentive but this will probably die out after a few days of testing. (For this reason the comparisons of N and P and N and W in the above example are alternated every two days - also the direct comparison between P and W provides a check). The period of testing should therefore be long enough for novelty effects to wear off and for workers to settle down into a normal routine of working. A minimum programme of 6 days is

[4] These are largely based on the procedures developed by Simon Ramm and Edward Opoku-Mensah.

recommended to compare 2 sets of tools on a particular activity.

Tools:

4. factors other than the variable to be compared should be balanced out. For instance if blades are to be compared, as in the effect of wear of the blades, then handles should be as identical as possible. This may mean fitting new handles to worn tools. If handles are to be compared then blades should be identical.

5. new and worn tools should be of the same brand and specification. The tools should be initially measured and the important dimensions from the ILO specifications recorded. The tools should be clearly numbered and a record kept of which tool is allocated to each worker - it is probably most convenient if each worker is allocated the same number tool each day (ie N1, P1, W1 etc ....). Tools should be photographed and a brief note made on the condition of each tool in terms of a grading - “poor”, “fair (average)”, or “good” - and any special features. This should also include a note on the quality of finish of the new tools.

6. tool maintenance is a factor which needs to be carefully considered and controlled, and may be a factor which is worth investigating. Where there is a routine maintenance programme this should be continued equally for the tools being compared and an additional test series might be carried out to compare maintained tools with similar but non-maintained tools. If tools are not routinely maintained then an additional set of tests might be carried out to investigate the effect of maintenance (mainly dressing and sharpening of cutting edges).

7. if tools break during the test, this should be recorded and the time taken to repair or replace the tool noted and deducted from the task time.

8. with 16 or more workers (2 groups of at least 8) in a test it is probably impossible to have uniform soil conditions for them all. Workers from each group should therefore be placed alternately so that the conditions average out as much as possible.

9. if there are obvious significant obstacles, for instance roots or rocks, then these might be removed prior to the test. Another option is to have a separate task force to help in removing obstacles met during the test, the time taken being deducted from the task time. This should be noted on the results sheet. In the worst cases where the conditions have obviously made the results non-typical - either too easy or too hard - this should be noted and possibly the result ignored.

Additional information:

In addition to task times other useful comments and observations should also be recorded. For example:

- Feedback from workers:
  - condition at end of test - “not tired”, “little tired”, “very tired”;
  - aches and pains - “none”, “few” or “not bad”, “many” or “bad”;
  - note of injuries from using tools such as blisters or cuts;
  - comments on the performance of the tools and problems experienced;
  - comments on the difficulty (hardness) of the task
- observations of any particular problems experienced by workers such as excessive bending and stooping; differences in work rates for new and worn tools (shovelfulls, scoops or blows per minute); inefficient tools or methods; etc .....

ANNEX 1 : TEST RESULTS FOR DITCHING ACTIVITY

Worker	**Adjusted time* for task (hrs/mins)**	**Worker condition**	**Aches/pains**	**Other comments**
Day 1: Worn Tools - Group 1				
FA (2½)	3hr 05	tired	waist pains due to tools	tool too blunt - needs a lot of effort
BA (2)	4h 07	very tired	chest pains hand hurt	doesn't like old tool - extra effort
SM (1½)	4h 30	very tired	chest pains hand blistered	has to exert more effort due to poor tool
YA(1½)	3h 33	tired	none	tool keeps bending (shovel) has to keep straightening it
IQ (¼)	3h 59	very tired	blisters handle not smooth	tool too blunt
KD (½)	5h 15	very tired	waist pain	tool not sharp enough not good for ditching
Day 1: New Tools - Group 2				
RF (2)	2h 40	not tired	none	very neat
YD (1½)	2h 44	little bit	none	"
JA (3)	2h 26	tired	none	-
AB (1½)	2h 43	little bit	none	-
JN (¼)	4h 45 (inexperienced)	tired	none	lot of delay due to lots of roots
YM (1½)	2h 44	little bit	little muscle ache	-

* adjusted time is total time for task less time lost in removing roots and/or breakage of tools

( ) relevant experience of working in years

TEST RESULTS FOR DITCHING ACTIVITY

Day 2: New Tools - Group 1				
Worker	**Adjusted time for task (hrs/mins)**	**Worker condition**	**Aches/pains**	**Other comments**
FA	2h 48	very tired	none	soil very heavy due to overnight rainfall
BA	3h 50	very tired	none	"
SM	3h 08	not tired	little	"
YA	4h 25	very tired	little	"
IQ	4h 25	very tired	some	"
AD	3h 37	tired	aches a bit	"
Day 2: Worn Tools - Group 2				
RF	4h 10	very tired	no data	soil heavy due to overnight rainfall
YD	4h 30	very tired	"	"
JA	3h 33	very tired	"	"
AB	3h 40	tired	"	"
JN	5hr 15	very tired	"	"
YM	4hr 35	very tired	"	"

TEST RESULTS FOR DITCHING ACTIVITY

Day 3: Worn Tools - Group 1		
Worker	**Adjusted time (hrs/mins)**	**Worker condition**
FA	4hr 23	very tired
BA	5h 30	very tired
SM	5h 15	little tired
YA	5h 35	little tired
IQ	5h 50	very tired
KD	5h 05	little tired
Day 3: New Tools - Group 2		
RF	4h 02	little tired
YD	4h 15	little tired
JA	4h 00	very tired
AB	3h 50	little tired
JN	6h 10	very tired
YM	4h 22	little tired

ANNEX 2: RESULTS FOR SLOPING ACTIVITY

Day 1: New Tools - Group 1			
Worker	**Adjusted time to complete task (hrs/mins)**	**Worker condition**	**Comments**
FA	2hr 00	very tired	low-lying area/shallow drains
BA	2hr 00	very tired	-
SM	3hr 20	little tired	-
YA	3hr 05	little tired	low-lying area/shallow drains
IQ	3hr 00	little tired	-
KD	4hr 30	very tired	rocky area
Day 1: Worn Tools - Group 2			
RF	2hr 30	little tired	low-lying/shallow drains
YD	2hr 30	not tired	low-lying shallow drains
JA	2hr 45	very tired	-
AB	3hr 10	little tired	-
JN	4hr 20	very tired	-
YM	4hr 00	very tired	-

RESULTS FOR SLOPING ACTIVITY

DAY 2: Worn Tools - Group 1			
Worker	**Adjusted time to complete task (hrs/mins)**	**Worker condition**	**Comments**
FA	3hr 00	very tired	-
BA	3hr 05	very tired	-
SM	3hr 10	little tired	-
YA	2hr 35	very tired	-
IQ	3hr 05	very tired	-
KD	3hr 45	very tired	-
Day 2: New Tools - Group 2			
RF	2hr 15	little tired	hard surface
YD	2hr 00	little tired	-
JA	2hr 35	very tired	-
AB	2hr 15	little tired	-
JN	3hr 20	little tired	-
YM	3hr 05	little tired	-

RESULTS FOR SLOPING ACTIVITY

Day 3: New Tools - Group 1			
Worker	**Adjusted time to complete task (hrs/mins)**	**Worker condition**	**Comments**
FA	2hr 17	very tired	-
BA	3h 30	very tired	-
SM	4hr 10	very tired	-
YA	2hr 52	not tired	-
IQ	4hr 25	very tired	hard surface (fused laterite)
KD	3hr 25	little tired	-
Day 3: Worn Tools - Group 2			
RF	2hr 00	not tired	-
YD	3hr 05	very tired	-
JA	2hr 55	very tired	-
AB	3hr 35	little tired	-
JN	4hr 20	very tired	-
YM	3hr 15	little tired	-

ANNEX 3 : DETAILS AND DISTRIBUTION OF INDIVIDUAL WORN TOOLS

Group 1 Worker	Shovel Details			Pick-axe details			Group 2 Worker
	Blade size a x b[1] (cm)	**Handle length (cm)**	**Relative quality [2]**	**Blade length a x b [1] (cm)**	**Handle length (cm)**	**Relative quality [2]**	
1Q	21 x 24	74	4	15 x 13	87	4	RF
YA	23 x 23	72	5	15 x 13	87	3	YD
FA	17 x 23	64	2	16 x 15	83	5	JA
BA	20 x 23	63	3	14 x 14	77	5	AB
SM	18 x 23	61	3	15 x 15	87	3	JN
KD	18 x 23	72	3	14 x 13	86	1	YM

(1) Dimensions ‘a’ and ‘b’ are shown in sketches on Page 5.

(2) “Relative quality” is a subjective assessment of the general condition of the tool graded out of 5.