Design innovations to simplify the regulation of animal-drawn mouldboard plows in Zambia

by

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Abstract

Many problems with the use of the ox-drawn mouldboard plow are caused by improperly adjusted regulators: farmers often do not understand how to set up this rather complex mechanism. Therefore, a regulator has been developed according to the design principle "form follows function". With the new design there is only one way to adjust plowing depth and this does not require tools. Thus plows are more likely to be properly adjusted, resulting in improved tillage and a lower energy requirement.

Introduction

Ox-drawn mouldboard plows are the most important farming implements after hand hoes in the Eastern Province of Zambia. However, operation of these plows is often problematic. The regulator of such a plow is rather a complex mechanism, and the most common reason for failure is that farmers do not understand how to use it correctly. Indeed, none of the farmers visited in Eastern Province used the regulator: it was either dismantled, or broken and not repaired. Instead, farmers use the wheel as a depth regulator, to push the plow out of the ground to the desired working depth. This causes overloading of the bearing unit (which is often poorly designed anyway), and excessive wear on the wheel axle so that the wheel can fall off. Another common problem is missing bolts and nuts. Many farmers do not tighten the bolts regularly, and often find it difficult to acquire new bolts or nuts to replace lost ones.

A new regulator has been designed according to the design principle "form follows function". In the new design, there is only one way to adjust plowing depth, and tools are not required to do so. Thus, plows are more likely to be properly adjusted, resulting in:

- a substantially decreased pulling force, thus reducing the burden on the oxen and increasing the area that can be plowed in a given time
- improved soil inversion and plowing quality
- decreased wear and tear of soil touching parts, leading to lower repair and maintenance costs
- easy handling of the plow for the plow operator.

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Evaluation of the problem

Regulator

The main cause of regulator malfunction is a consequence of how plows are transported. Many farmers drag their plow to the field, without using a sledge or cart. The regulator, and other parts, are damaged by being scraped along the ground.

The regulator is not replaced when it is worn out. Some farmers remove the regulator altogether because they do not understand its function. They hitch the chain direct to the beam because they think that depth adjustment should be done with the wheel (Photo 1).

On the *Rhino* plow ("Safim type", manufactured by Northland Engineering), depth and width are adjusted with just one bolt (Figure 1). But farmers often do not know how to operate the regulator (and many of them do not even own spanners), and there is no indication on the plow itself of how this should be done. As a result, when the bolt is

Figure 1: Safim type Rhino *plow showing regulator*

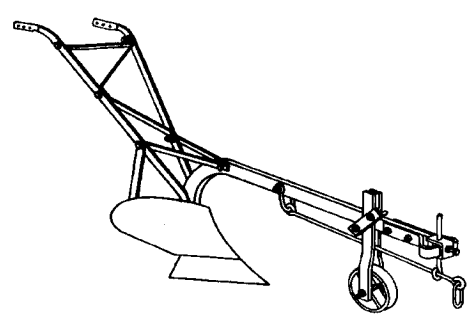


Photo: Paul Starkey

Photo 1: Farmer plowing in Zambia with the regulator of the Safim type plow removed and the chain attached directly to the beam

loosened, half the regulator falls apart. The design of the Lenco regulator is much better. Its width and depth are independently adjustable without tools. Its design indicates by its form that a vertical and a horizontal adjustment can be made.

Compared with the depth regulator, the horizontal width regulator is more easy to understand. When walking behind the plow, the operator can see what happens when the hitch point is moved sideways.

Ergonomic "incompatibility"

Adjustment of the plowing depth should be done with the depth regulator. Before that, however, the steadying wheel should be raised to its highest point. Then a short furrow should be plowed and its depth observed. If the furrow is too deep, the position of the regulator should be lowered slightly. Then another few metres must be plowed and the depth observed again. This procedure is repeated until the desired plowing depth is achieved. The steadying wheel is then lowered again until it just touches the soil surface.

None of the farmers or agricultural extension workers interviewed in Eastern Province knew anything about this procedure. It was generally thought that adjustment should be done by raising or lowering the steadying wheel. The functioning of the regulator is completely unknown. As mentioned above, many farmers simply hitch the draw chain directly to the plow beam. Even when the regulator performs well, the draw bar is set parallel to the beam, so the plow is set for deep plowing and the wheel is, wrongly, used to correct this.

Two ergonomic problems have been mentioned here, causing inefficient plowing.

- it is not clear to the farmers or the agricultural extension workers that the steadying wheel should be fully raised while setting plowing depth with the depth regulator
- the process by which depth should be adjusted with the regulator is unclear. In ergonomics language, its use is "incompatible" with its function: to plow deeper, the regulator must be moved up. It would seem to be more "common sense" to lower something in order to make the plow work deeper.

Solutions

The combination of the two ergonomic problems mentioned above provides the basic idea for a simplification of the regulator design. The steadying wheel and the regulator are integrated to make the depth adjustment device compatible with its function.

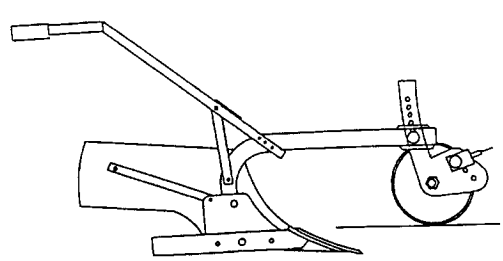
Although moving up the regulator does not look obvious, moving up the wheel is generally done by the farmers to increase the working depth. This is explained by the fact that, in our perception, the regulator refers to the plow, which has to go down, whereas the wheel refers to the distance between the soil surface and the plow beam.

In the theoretically ideal case, as indicated in Figure 2, the depth adjustment bar has a curved shape. As a result, the wheel and the hitch point will describe a circle when being adjusted. The hitch point is located closer to the centre of the circle than the wheel. Thus, its height will change less than that of the wheel when the plow is adjusted. A more elaborate explanation of the functioning of the integrated regulator is given in Helsloot (1987).

The five holes in the adjustment bar allow the plow to work at five different depths (5, 7.5, 10, 12.5 and 15 cm). Minimum workable plowing depth is 5 cm and most farmers plow between 8 and 12 cm. Plowing deeper than 15 cm is too heavy for oxen.

As oxen pairs differ in size, it must be possible to change the height of the hitch point without moving

Figure 2: Initial concept of the new regulator



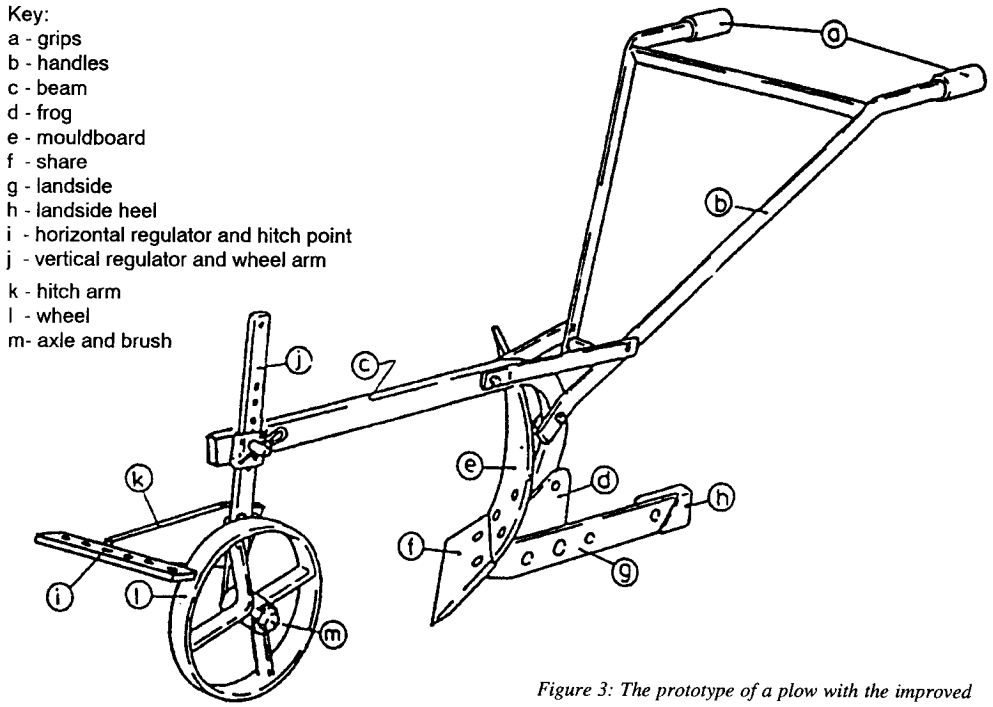


Figure 3: The prototype of a plow with the improved regulator as submitted to Magoye for testing

the wheel bar. The three holes in front of the wheel are the hitch points relating to the different ox sizes. It can be seen that some parts have been eliminated, making the plow somewhat lighter and cheaper.

Test results

Some work has been done to simplify production of the regulator. The intention was to build the regulator out of parts readily available in many countries. Therefore, a prototype has been made with a straight wheel arm (see Figures 3 and 4). The wheel arm extension was screwed on, instead of cutting the whole arm out of one piece. By making the extension plate rotate, the width adjustment could be welded on.

A prototype of the implement described has been made by Rumptstad. This was subjected to tests by the Animal Draft Power Research and Development Project in Magoye, Zambia. The project concluded (Meijer and Simuyemba, 1991) that:

> "The concept of the depth/width adjustment system used on this implement is promising. Taking into consideration that most owners of conventional ox-drawn plows remove the depth and width regulators, connect the chain directly onto the plow beam and adjust working depth by moving the wheel up or down, the Helsloot design offers an alternative that might prove acceptable to both farmers and engineers. Depth adjustment

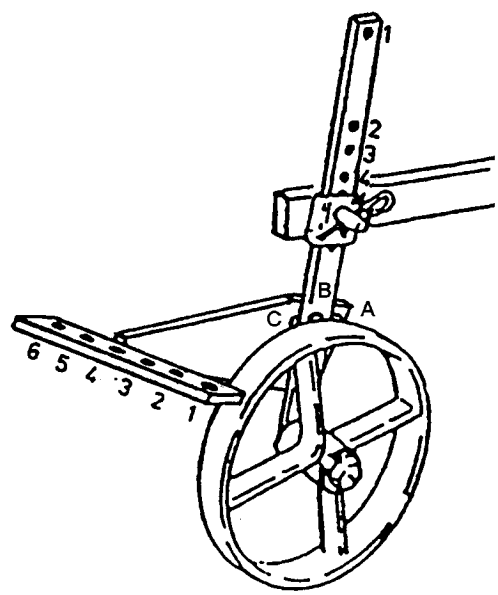


Figure 4: Detail of the prototype regulator as submitted to Magoye for testing

> can be done in the simple way most farmers are used to, by raising or lowering the wheel, while this action will simultaneously raise or lower the hitch point. As a result, depth adjustment can be easily explained and easily remembered. The implement's unconventional appearance, however, will for many farmers take time to get used to."

It was also mentioned that:

> "Handling the plow is easy and it is light to lift. ... Setting the working depth by means of the wheel arm is, like width adjustment, easy and requires no tools. ... Position B of the hitch arm [see Figure 4] seems to offer the combination of best depth range, lowest draft requirements and fair stability."

Conclusions

The main improvement of this new regulator is that there is only one way to change the plowing depth because the depth regulation mechanism and the steadying wheel have been combined. The way farmers are used to adjusting the plow, which until now was wrong, has become the right and only way to adjust it. For that reason, someone who has never plowed before will also adjust the plow properly.

If a hitch point is chosen that does not accord to the size of the oxen, everyone will notice that something is wrong. Either the wheel will not touch the ground, or the plow will not enter the soil.

References

Helsloot H, 1987. *Design of small-scale farm equipment for rural Zambia.* MSc Thesis. Department of Industrial Design Engineering, Delft University of Technology, Delft, The Netherlands. 158p.

Meijer R A and Simuyemba J, 1991. *Results of tests conducted with the Helsloot/Rumptstad prototype ox drawn mouldboard plow.* Animal Draft Power Research and Development Programme, PO Box 11, Magoye, Zambia. 15p.