Development of an animal-drawn puddler for rice production on the Usangu Plains of Tanzania

by

M L Lecca, I A Kinyaga and J B Bunyinyiga

Usangu Village Irrigation Project, PO Box 336, Mbeya, Tanzania

Abstract

Where rice is grown under irrigation, puddling—churning soil with water to achieve suitable conditions for transplanting rice seedlings—is a difficult and time-consuming operation. A survey of farmers on the Usangu Plains of Tanzania found that this work requires between 350 and 700 hours/ha using hand hoes.

The Usangu Village Irrigation Project has designed and fabricated an animal-drawn rotating puddler. Tests of this puddler in the Majengo Scheme showed that the implement had an effective field capacity of 0.047 ha/hour using a pair of oxen, and a labour requirement of 43 hours/ha. Farmers were pleased with both the rate and the quality of work. A labour bottleneck might be considerably reduced if this implement were adopted. The cost of the implement in 1991 was about 20 000 Tanzanian shillings (US$ 87).

Introduction

In many developing countries, the human population is growing faster than agricultural production. Most agriculture is in the hands of small farmers, who are generally poor and depend mainly on hand-hoe technology. Thus farms are small and production is low; most small farmers produce just enough for household consumption, with very little, if any, surplus. To overcome this constraint, small farmers need to intensify the use of animal power technology.

In Tanzania, draft animals are used mainly for land preparation, notably primary tillage. Although they could be used for many other farm operations, such as harrowing, levelling, puddling, sowing, threshing and transport, this is not common practice.

The Usangu Plains, located in Mbeya Region, cover an area of about 15 500 km^2, of which 7900 km^2 have potential for rice production. Swamp rice is grown in lowland areas by smallholder farmers. After plowing, suitable conditions for transplanting rice seedlings are created by puddling—churning soil in the presence of excess water. Puddling reduces leaching of water, kills weeds and makes the soil softer and ready for transplanting. However, as this work is generally done manually using hand hoes, it takes a very long time. A sample survey of farmers in the area of study indicated a labour requirement of 350–700 hours/ha (Bunyinyiga, 1989).

In order to speed up land preparation and reduce the burden on the farmer, a simple animal-drawn rotating puddler has been designed, fabricated, tested and demonstrated to farmers (Photo 1).

Photo 1: The animal-drawn rotating puddler in use

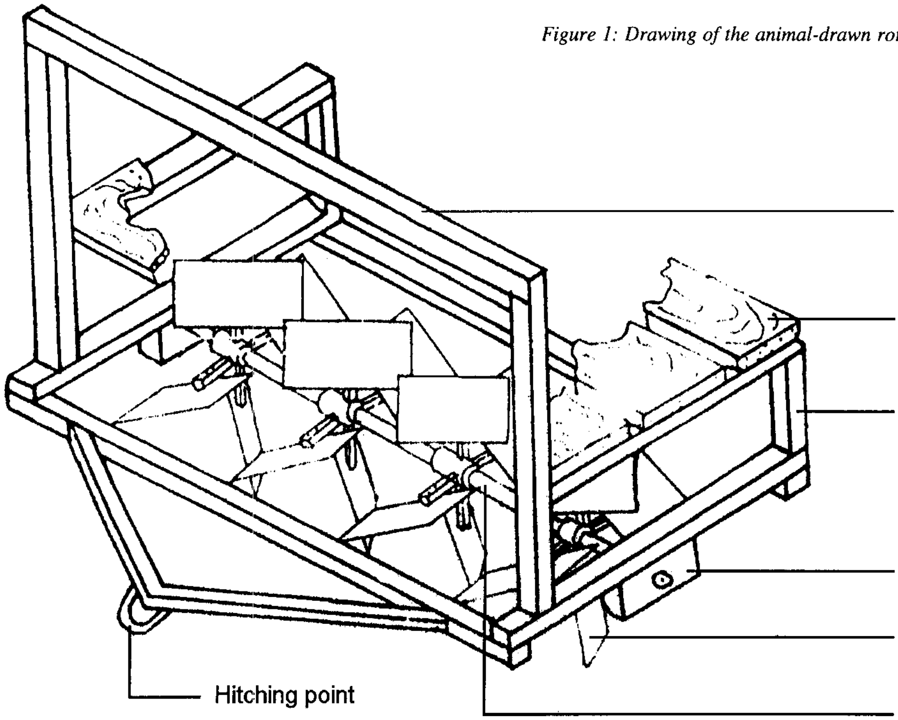

Figure 1: Drawing of the animal-drawn rotating puddler

Description and operation of puddler

The puddler frame has three parts: an operating blade axle support, a hitching point and an operator post (Figure 1). Most parts are welded to the frame.

The operating blade axle is similar to the device used in Indian puddlers. It consists of four equidistant hubs with four perpendicular blade-supporting fingers welded to it (Photo 2). The blade axle rotates on two wooden bearings which are fixed to the frame by bolts. The operating blades are fixed to the fingers by bolts. Both the bearings and the blades can be easily and cheaply replaced when they wear out. Two bushes are fixed on both sides of the blade axle to keep it well centred on the frame.

The frame of the implement is made of hollow rectangular steel sections. Four supporting crossed-finger bladed hubs were fabricated in the nearby workshop of the Mbeya Oxenization Project. The materials used are summarised in Table 1. The cost of the implement in late 1991 was about 20 000 Tanzanian shillings (US$ 87).

The rotating puddler is pulled by draft animals guided by an operator. The blades sink and roll in the flooded plowed soil, breaking the clods and making a layer of mud. The blades also cut weeds, roots, straw and stubble and submerge them in the

Table 1: Materials used in puddler construction

Materials	*Quantity*
Hollow rectangular steel section for frame (25 x 50 mm) by mm	8040
Arc welding rods (2.5 mm) by kg	1
Timber for platform (pieces 25 x 150 x 1100 mm)	4
Bolts and nuts for fixing timber to frame (10 x 40 mm)	8
Bolts and nuts for fixing wooden bearing to frame (10 x 75 mm)	4
Wooden block axle bearing (50 x 150 x 70 mm)	2
Metal plates for wooden bearings (3 x 50 x 150 mm)	2
Hollow round steel for hubs (68 mm external diameter, 29 mm internal, 79 mm long)	4
Solid steel square bar (25 x 25 x 80 mm or 30 x 30 x 80 mm) for blade finger support	16
Steel plates (3 x 130 x 240 mm)	16
Bolts and nuts [or rivets] (10 x 40 mm) for fixing blades on fingers	32
Rivets for fixing bladed hub on the operating axle (10 x 50 mm)	1
Axle bush (46 mm external, 30 mm internal, 120 mm long)	1
Axle bush (46 mm external, 30 mm internal, 70 mm long)	1
Axle galvanised pipe (29 mm external diameter, 1100 mm long)	1

Table 2: Results of field trials with puddlers

		Recorded values		
Parameter	*Units*	*Buffalo pair*	*Oxen pair*	*Remarks*
Field capacity	ha/hour	0.154	0.047	Oxen frequently sank in the flooded plots
Field efficiency	%	74	34	Achieved efficiencies were low due to both animal and operator inexperience
Effective working width	mm	900	500	Measured as average of four passes. The overlap was excessive when using the ox team
Implement draft (force)	N	900	800	Measured with spring dynamometer
Working speed	m/s	0.55	0.25	Measured at different times
Puddling depth	mm	100–150	100–150	Estimates only
Labour requirement	hours/ha	11	18	Water buffaloes performed better than oxen. Labour using only hand hoe is about 350 hours/ha

mud where they can decompose. When there is a lot of grass in the field, a comb harrow should be used before puddling. The harrow can also be pulled by a pair of animals.

Testing procedures

The rotating puddler was first tested in the Majengo Scheme of the Usangu Village Irrigation Project, during the rainy season of 1990. Seven farmers' plots and one plot in the Project's experimental field were used for the tests. The rectangular plots were about 200 m^2, ranging from 8 x 25 m to 10 x 20 m. All the plots were plowed before flooding with ox-drawn mouldboard plows. Each plot was flooded with water one week before plowing with animal-drawn mouldboard plows. A layer of water 50–100 mm deep was maintained. One of each

Photo 2: View of the puddler from underneath

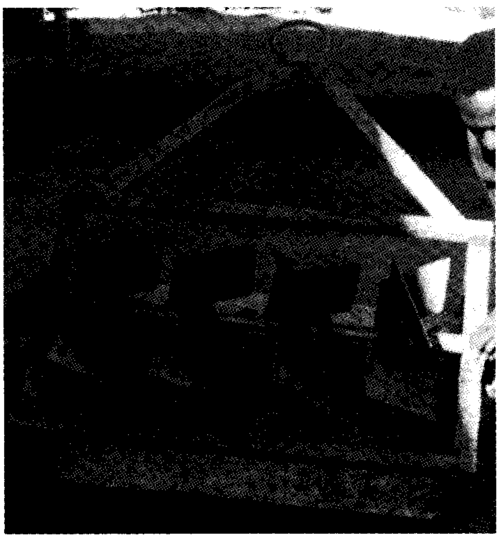

Photo: I A Kinyaga

farmer's plots was puddled with a pair of oxen, the other was puddled using a pair of buffalo. The animals worked only in the morning. Two people worked with the animals: a driver, usually standing on the draft implement, and an assistant encouraging the animals.

Measurements were taken of area worked, time taken, working speed, working width, depth of puddling, draft force and labour requirement. In calculating field capacity (area cultivated per unit of time), turning time at the headlands was included, but stops of more than two minutes (for any reason) were not included. The effective field capacity (working rate while actually moving) was calculated for one passage of the implement.

Field efficiency (actual rate of work as a proportion of theoretical rate) was calculated according to the test code of the Regional Network for Agricultural Mechanization (RNAM, 1983). Average working speed was calculated by measuring the time required to puddle a distance of 15 m. Force was measured twice in each plot, at different times, using a spring dynamometer. The effective width was taken as the average of the working widths of four implement passages. Precise measurement of puddling depth was difficult, and so only estimates could be made.

Results

The puddler performed well in fields with a layer of water of about 100 mm. A single passage of the implement churned the soil sufficiently to provide reasonably good conditions for transplanting paddy seedlings. The trial results are summarised in Table 2.

Working speed, effective field capacity and field efficiency were all higher with water buffaloes than with oxen. Oxen seemed reluctant to work in flooded plots and usually stopped when they sank more than 300 mm into the mud. The theoretical working width of the implement is 1000 mm; the differences in effective working width were due to greater overlap using oxen (50%) than using buffaloes (10%). The depth of puddling was similar for both oxen and water buffaloes, as it was based on the vertical length of the blades on the rotating axle. The recorded implement draft (force) was 900 N when pulled by a pair of water buffaloes and 800 N when pulled by oxen. The difference between the forces was thought to be due to the increased pulling angle for buffaloes since they were taller than the oxen. This might have also affected implement depth.

Some recommendations

Construction of the hub assembly and blades required a special tool, made by the Mbeya Oxenization Project. A simpler method of construction would be desirable. The hitching point should be higher for the implement to remain horizontal when operating, otherwise the puddler tilts backward and begins to collect debris behind it. However, this modification must not complicate the frame. Since bolts and nuts are expensive in the area, they should be replaced by rivets which can be made locally from scrap round bars.

In order to reduce wear on the blades and wooden bearings, the puddler should be transported to the field on a sledge pulled by draft animals.

Field efficiency could be increased by more and better training of both the operator and the animals. Improving the skill of the operator in simultaneously guiding the animals and the implement should increase the effective working width by reducing the overlap.

In order to gain further feedback and information on the potential for using these rotating puddlers, more prototype implements should be fabricated and made available for use by smallholder farmers.

References

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