4

Farming Operations

4.1 PLOUGHING

Ploughing is probably the most important operation undertaken by draught oxen in Africa. Certainly in Sierra Leone ploughing is the main justification for keeping work animals and farmers in the Koinadugu and Bombali Districts use their animals for both ploughing and harrowing in swamp, boli and upland soils. Ploughing with oxen is much quicker than hand hoeing; it leads to better weed control and the soil inversion results in the incorporation of organic matter.

Fig 4.1 **A field ploughed by oxen at Musaia Livestock Station, January 1981.**

4.1.1 Type of plough

With very large animals, it is possible to use disc ploughs, reversible ploughs and twin furrow ploughs, but with the small Ndama oxen only the single mouldboard plough can be considered suitable. The parts of a typical mouldboard plough are named in *Fig 4.2*. A wheel is illustrated, but a skid can be equally efficient and sometimes preferable. Further details of various ploughs are given in Chapter 5.

4.1.2 Adjustments to ploughs

The plough should be adjusted so that the share cuts an even furrow at a constant and appropriate depth. The importance of good adjustment cannot be overestimated, as a poorly adjusted plough will tire both oxen and operator and produce poor results, to the frustration of everyone.

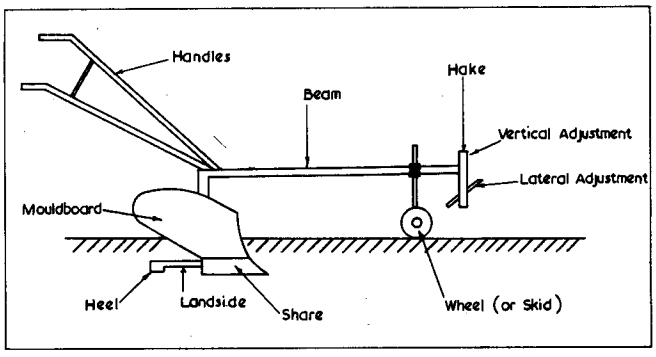

Fig 4.2 **A typical mouldboard plough.**

a) Wheel (or skid): The wheel or skid should be adjusted first to give the desired depth of ploughing. It is raised to increase or lowered to decrease the depth of ploughing. This is illustrated in *Fig 4.3*.

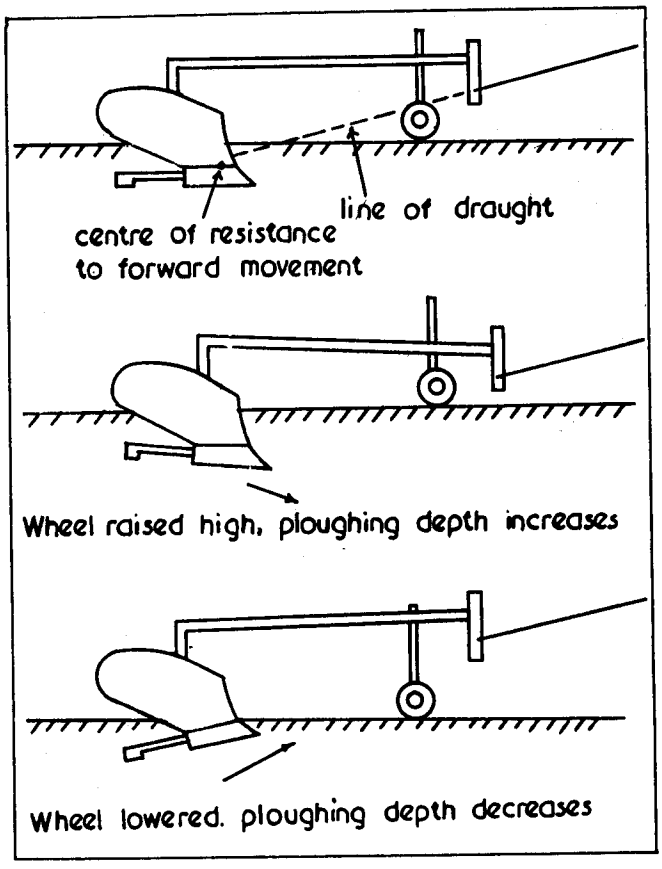

Fig 4.3 **Wheel (or skid) adjustment to control ploughing depth.**

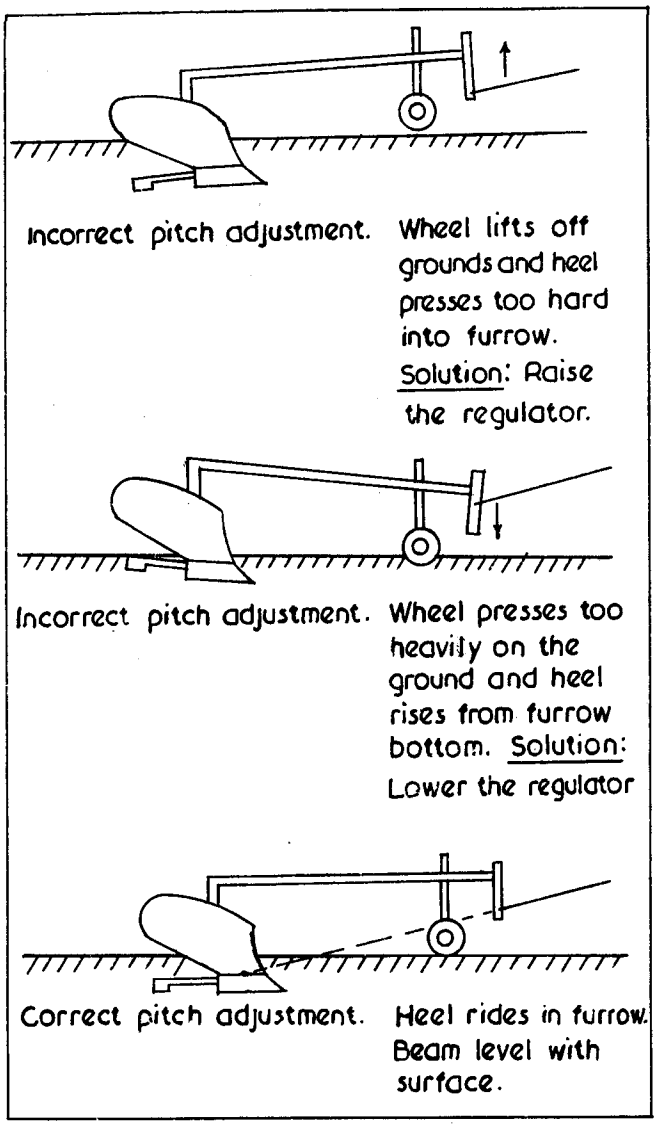

Fig 4.4 **Use of vertical regulator for pitch adjustment.**

b) Pitch: The traction chain can be attached to the vertical adjuster in a number of positions. The correct position is such that there is a straight line between the centre of the yoke, the attachment point to the adjuster and the centre of resistance of the plough *(Fig 4.4)*. If the wheel lifts off the ground and the heel presses into the furrow, the regulator should be raised. If the wheel presses heavily on the ground and the plough digs deep, lifting the heel from the furrow bottom, the regulator should be lowered, *(Fig 4.4)*.

c) Chain: Lengthening or shortening the traction chain from the yoke to the plough has a similar effect to the raising and lowering of the vertical regulator (hake). A short chain tends to lift the wheel and press the heel into the furrow, while a long chain tends to lift the heel and put the pressure on the wheel. This is illustrated in *Fig 4.5*.

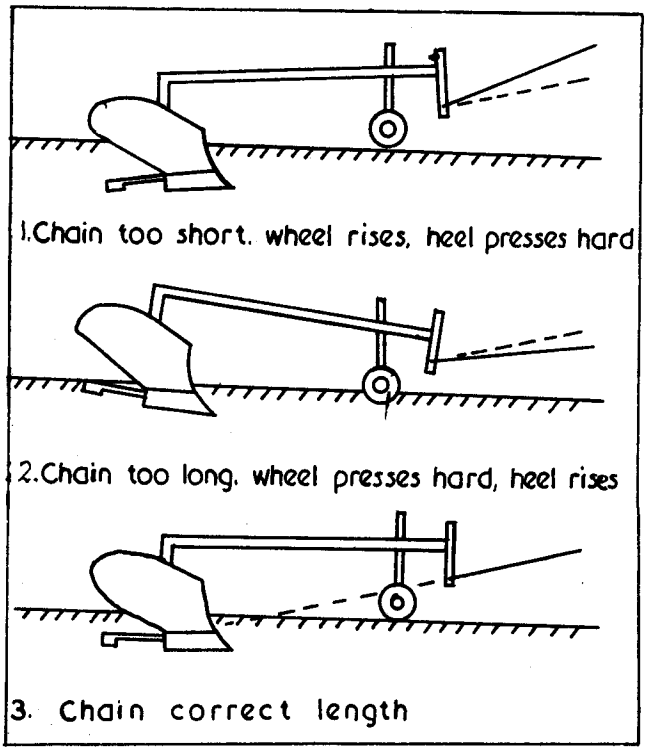

Fig 4.5 **Chain adjustment.**

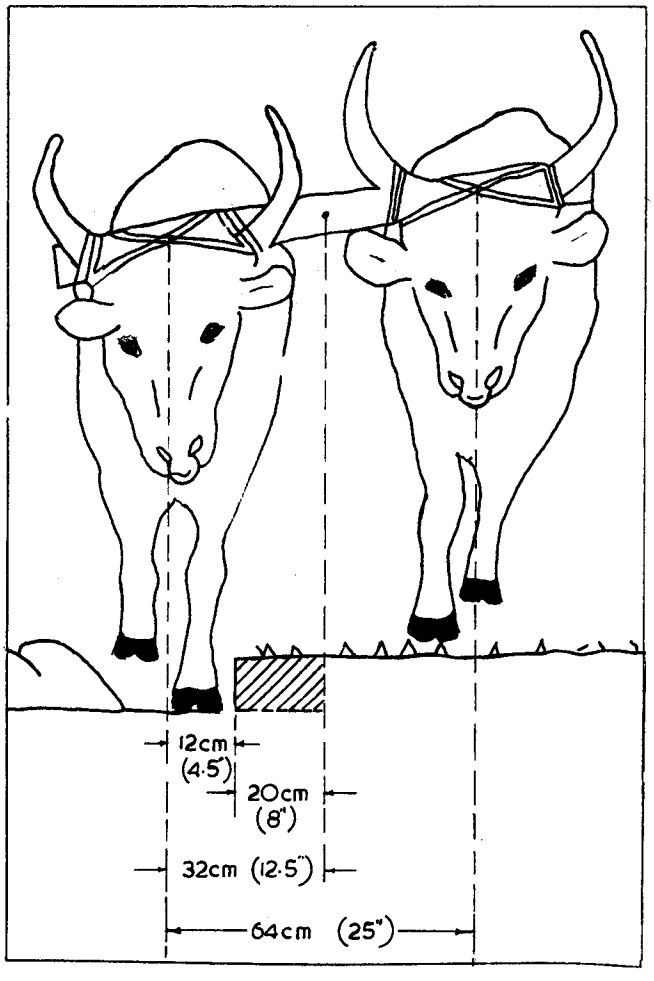

Fig 4.6 **Use of standard yoke and 20 cm/8" plough.**

d) Lateral: The lateral or horizontal adjustment may be used to change the width of the furrow. If a 20 cm/8" plough is used, together with the 64 cm/25" yoke designed for a 20 cm/8" plough and if the traction chain is attached to the beam in a central position, the furrow width should correspond to the nominal size of the plough, 20 cm/8", *(Fig 4.6)*. However if the chain is offset towards the unploughed land, the ploughing width is reduced, while if the chain is offset towards the furrow, the ploughing width is effectively increased *(Fig 4.7)*. The lateral regulator can also be used to compensate for plough sizes differing from the 20 cm/8" most suitable for the standard 64 cm/25" yoke. If a 15 cm/6" plough is used with the standard yoke, the chain attached to the lateral regulator can be offset towards the unploughed land, while if a 23 cm/9" plough is used the chain can be moved towards the furrow.

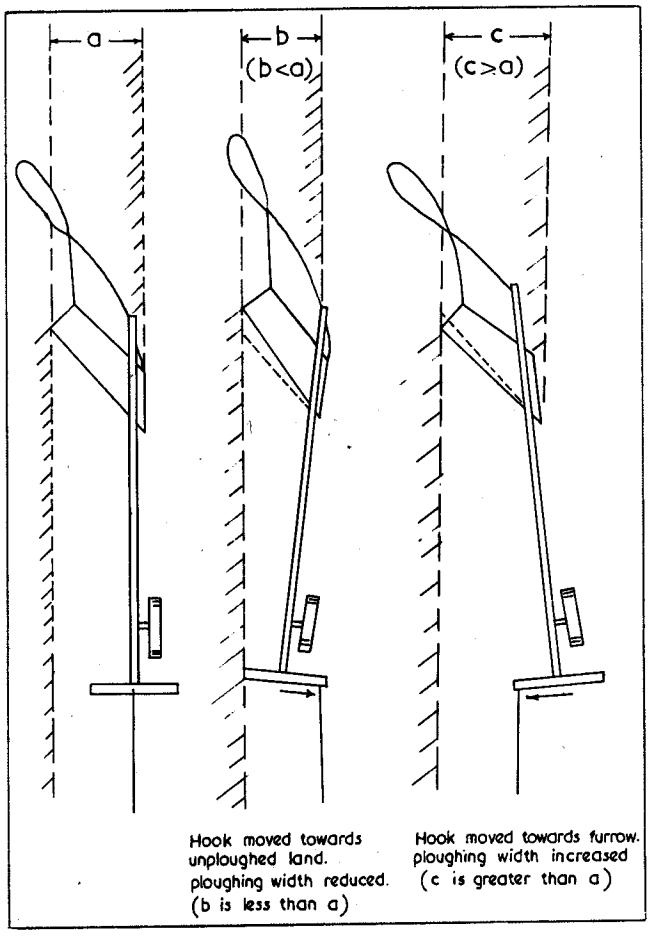

Fig 4.7 **Adjustment of ploughing width.**

4.1.3 Ploughing techniques

Ploughing with animals is most efficient in large fields, as the effort of stopping, turning and restarting is tiring for both oxen and operators. Animals can generally work 4-5 hours a day in light soils and in this time they can plough over 0.2 ha/½ ac of a large field, but perhaps only 0.15 ha/$\frac{1}{3}$ ac of small fields. However, in heavy soils and swamps the number of working hours is generally reduced to three to prevent the animals from becoming over-tired. Similarly, in poorly stumped fields, where the plough jolts against roots, the peaks of tractive effort caused by the stumps will tire the animals and reduce the daily average.

Ploughing is generally best carried out in large rectangular blocks of land, ploughing anti-clockwise round and round the block from the outside to a central, finishing furrow. However, to avoid leaving a ridge on the outside and a deep channel in the middle of the field where the two directions of soil inversion meet, the first and last furrows should be of reduced depth. Ploughing should follow the contour or cross the direction of slope and sloping land may be ploughed as several rectangular plots, with the long furrows crossing the slope as shown in *Fig 4.9*.

Fig 4.8 **Swamp ploughing.**

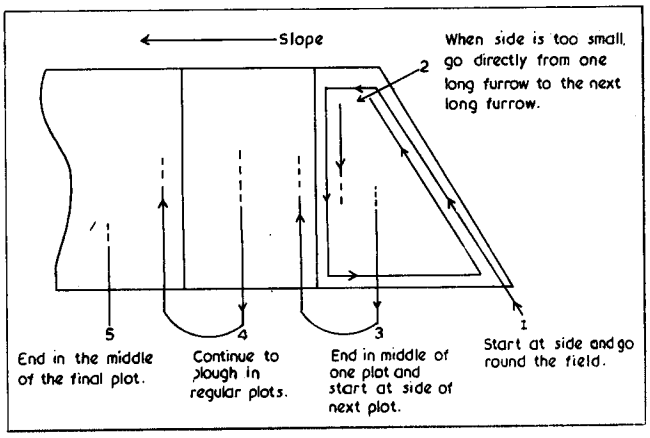

Fig 4.9 **A system of concentric ploughing for irregular land.**

Fig 4.10 **Upland harrowing with triangular spike tooth harrow.**

4.2 HARROWING

Harrows work at shallow depth and break up clods, providing a finer, looser seed bed than that achieved by ploughing. Three types of harrow available in Sierra Leone are described in Chapter 5. These are all tooth harrows with numerous vertical tines that are dragged through the soil surface. The three main functions of the harrow are seed-bed preparation, weed control and seed covering.

a) Seed-bed preparation: Soil is harrowed to produce a fine textured soil surface or seed-bed. This is generally carried out several days after ploughing to assist the breaking up of furrow clods by the weather elements. If two harrowings are performed, one should be along and the other across the field. If a seed drill is to be used, a fine seed-bed is essential to prevent the drill from becoming clogged.

b) Weed control: Many weeds germinate after ploughing, but harrowing one week later destroys most of these weed seedlings. In the Karina area, weed growth is so severe that farmers frequently plough the bolis three times. It is hoped to investigate the comparative effectiveness of several harrowings to a second ploughing in controlling these weeds, as three harrowings requires less time and effort.

c) Seed covering: If the seeds are broadcast the land can be harrowed to cover them. Seed covering of upland rice is the major, and sometimes only, harrowing operation carried out by farmers in the Bombali and Koinadugu Districts. This is a quick and relatively efficient method, although lacking the significant benefit of improved weed control that comes from row planting. Upland harrowing is relatively quick and, in 4.5 hours a day, a pair of oxen can harrow around 0.8 ha/2 ac. Only a single operator is needed for harrowing.

4.3 SWAMP PREPARATION: Harrowing, puddling, levelling

Trials at Njala show that Ndama oxen can be used successfully to prepare developed or semi-developed swamps for rice transportation. At present, farmers in the Bombali and Koinadugu Districts do not use oxen for swamp harrowing, puddling and levelling after ploughing, mainly because the swamps have not yet been stumped, or developed to allow water control. Cultivation techniques therefore differ from those of developed paddy fields and farmers in those Districts do not regard their metal zig-zag harrows suitable for work in swamps. However, the triangular harrow can be used in swamps to produce a fine soil texture that can be levelled by simply inverting the harrow.

Depending on the water level in the swamp and the number of days after ploughing, 2-3 harrowings followed by 2-3 levellings produce a good medium for rice transplantation. Harrowing a flooded swamp in 2-3 passes requires around 20 team hours/ha or 8 hrs/ac. Levelling in 2-3 passes requires 15 team hours/ha or 6 hrs/ac. However, walking in flooded swamps is tiring for oxen and pulling a harrow through them is as hard as swamp ploughing, *Table 4.1*. The working hours for these operations should be reduced to 3-3½ hours a day.

Fig 4.11 **Harrowing swamp with triangular harrow.**

Fig 4.12 **Swamp levelling with inverted spike tooth harrow.**

Table 4.1 - **Draught requirement for different implements**

(Units are deca Newtons, or kilogram force)

	Average draught requirement in different soils (with mean maximum - dN)		
Implement	*Gravelly upland*	*Moist swamp*	*Flooded swamp*
Ploughs (12 cm depth)			
7" Guinea	60 (70)	-	70 (85)
9" Chinese	-	-	90 (135)
6" Anglebar + wheel	60 (70)	-	70 (90)
9" -do-	80 (90)	-	90 (110)
6" Pecotool + skid	65 (75)	-	-
6" Houe Sine + wheel	60 (70)	-	-
8" -do-	65 (80)	75 (90)	85 (100)
8" Houe Sine + skid	70 (80)	-	70 (85)
9" -do-	80 (90)	-	-
Weeders (3 tines, 5 cm depth)			
Anglebar	70 (85)	-	-
Houe Sine	60 (70)	-	-
Ridgers (60 cm ridges on ploughed land)			
Anglebar	80 (90)	-	-
Houe Sine	75 (90)	-	-
Groundnut lifters			
Anglebar	60 (75)	-	-
Houe Sine	70 (90)	-	-
Harrows (8 cm depth)			
Triangular, with log	70 (75)	80(100)	85 (105)
Chinese	-	-	60 (70)
Levellers			
Triangular, with log	50 (55)	50 (65)	40 (45)
Chinese	-	-	30 (40)

* *10-20 cm water*

4.4 SEEDING

Oxen can be used to pull a seeder which sows seeds at specific spacing in parallel rows. Planting with a seeder is quicker than planting by hand and produces straight rows with even spacing. The main advantage of using a seeder is that the parallel rows can be easily weeded by an ox-drawn weeder and weeding is a vitally important operation.

A single-row precision seeder has been tested at Njala and has been used successfully to plant upland crops including maize, groundnuts, cowpeas and rice, *(Figs 4.13, 4.14)*.

This seeder could probably also be used for swamp rice, if seeding were to be carried out before flooding. The seeding operation is simple. *Along-the-row* spacing is determined by the seed distribution disc which is adjustable for different crops. Seeds are placed in the hopper and the oxen walk in a straight line pulling the seeder which meters out the seeds into the disturbed soil, and then covers them over. *Between-row* spacing is determined by an adjustable guide which is pulled along the ground. The mark made by this guide is followed exactly by the seeder when when planting the next row; this ensures equidistant rows.

The work involved in pulling a seeder is relatively light and a single ox can be used. Working hours may thus be extended to 5-6 hours a day, allowing 0.4-0.5 ha/day or 1-1¼ ac/day for a seeding operation.

Fig 4.13 **Planting groundnuts with a Super Eco seeder.**

Fig 4.14 **Planting upland rice with a Super Eco seeder**

Since ox-weeding can greatly improve the efficiency of upland farming, ox-seeding is an excellent way of preparing the necessary straight lines. In Sierra Leone the exact time of planting is not very critical, unlike countries like The Gambia and Senegal, which have a short rainy season. It is possible for the small farmer to hand plant in straight rows using a marking rake or a long rope, which saves the expense of an ox-drawn seeder. However, Chapter 7 discusses the economic justification of ox-seeding combined with ox-weeding which can lead to cost savings of up to 40% compared with hand operations. The ox-seeder by itself is only economically justified on large farms of over 4 ha, or 10 acres.

Fig 4.15 **An ox-team weeding between rows of cowpeas.**

4.5 WEEDING

Weed growth is a major factor limiting crop production in Sierra Leone and hand-weeding operations account for much of the cost of upland farming. However, if crops are planted in parallel rows, good results can be achieved by ox-drawn weeders. These comprise three flexible tines fitted with broad 'ducksfoot' shares. The shares are 15 cm/6" wide, and three shares in a triangular formation sweep weeds to a width of about 50-55 cm/ 20-22", at a soil depth of about 5 cm/2". This is excellent for crops such as maize, groundnuts and cowpeas planted in rows 66 cm/ 26" apart, *(Fig 4.15)*. Further work is required to identify a good system for weeding upland rice in close rows.

For all weeding, good ox-control with well trained animals is required to ensure that they walk in straight lines between the rows. Oxen can be used singly or in pairs and, as the draught power is relatively low (60-70 kg) and fairly constant, animals can work for 5-5½ hours a day, weeding 0.6 ha/day or 1.5 ac per day.

Weeds should be less than 5 cm/2" high, and the speed of weeding with oxen allows for two or three weedings to be carried out during the growing season, with less time taken in these operations than by a single hand-tool weeding. Some weeding will also be necessary along the crop rows. To protect attractive crops like maize from being eaten by oxen during weeding operations, it is recommended that the animals should be muzzled. This can be achieved simply by covering the animals' mouths with pieces of sacking tied to the horns, *(Fig 4.16)*.

Fig 4.16 **A single ox, with muzzle, weeding maize.**

4.6 GROUNDNUT LIFTING

Ox-drawn groundnut lifters are available and have been used successfully at Njala. Oxen walk between the rows and pull a share that passes under the groundnut plants and lifts them to the surface for harvesting. The ox-lifting operation is twice as quick as hand-lifting, much less tiring for the operators and achieves comparable results. Groundnut lifting, however, is more difficult if there are many weeds around the groundnut plants. As it is fairly hard work, only 3-4 team-hours a day should be attempted, during which time about 0.3 ha/0.8 ac of groundnuts can be lifted.

Fig 4.17 **Making ridges with oxen.**

4.7 RIDGING

Oxen can pull mouldboard ploughs that turn the soil to both sides at the same time, making two half ridges. By returning from the other direction alongside the previous furrow, one ridge is completed while half the next ridge is also made, *(Fig 4.17)*. Thus, for ridging, the oxen move up and down the field as opposed to round and round the field. In very light soils ridging ploughs can make ridges from unploughed land, but the work is harder as the ridger is effectively acting as a double plough. The gravelly soils at Njala, as in many other places in the country, makes this ridging of unploughed land very tiring for the animals.

It is therefore recommended that the land should first be ploughed before ridging. Although requiring two operations, this method is quicker than ridging with hand tools. The

mouldboards or wings can be adjusted to vary the width and height of the ridges. Ridging also requires a longer yoke than that used for ploughing, with a nominal yoke size of 90 cm/35" for making 64 cm/24" ridges. With this yoke one ox walks in the previous furrow, but the normal ploughing yoke can be used if one ox is made to walk on top of the previous half-ridge. If they are ridging previously ploughed land, oxen can work a 4-hour day, covering about 0.3 ha/0.8 ac.

Fig 4.18 **An ox-cart carrying farm produce.**

4.8 TRANSPORT

Oxen can be trained easily to pull carts, carrying both the operator and a good load of up to 0.8 tonne on reasonable tracks, *(Fig 4.18)*. At Njala, ox-carts are used to carry cultivation equipment to ploughing sites over 3 km/1.8 miles away; they also carry farm produce and inputs and have some private domestic uses. Where sufficient roads or tracks are available, carts could fulfil a most useful role in villages, carrying equipment, materials, farm produce, fuel, wood or water. Ox-carts are likely to be of more value in the north of the country where bush regrowth is less rapid and tracks to swamps and bolis can be kept open more easily.

As carting generally involves periods of waiting during loading and unloading, it is not possible to generalise on the hours of work, but three hours of pulling during a 6-hour period is probably not excessive when the animals are in good condition. The animals will become more tired if the load is not well balanced and if the work involves pulling on rough or muddy ground or up slopes.

4.9 MEASUREMENT OF POWER REQUIREMENTS

The power requirement of different operations can be measured with a dynamometer mounted between the traction chain and the equipment in use. During early trials, a simple dynamometer was made from a heavy spring that had been calibrated using weights so that the force could be estimated by the degree of expansion on the spring. However, there were considerable difficulties involved in taking readings from this during farming operations. The project was then fortunate to obtain the use of a hydraulically operated dynamometer from the National Institute of Agricultural Engineering (NIAE), UK. This dynamometer has a separate dial, making readings relatively simple, *(Fig 4.19)*. During normal work, the power employed is constantly changing with the variations in the soil, the implement depth and the effort of the oxen. The constantly changing dynamometer reading is used to determine firstly the average effort (the mean of instantaneous readings) and the mean maximum effort (the mean of the maximum of work fluctuations during normal working).

Information obtained on the power requirements for different operations and implements is presented in *Table 4.1*.

Fig 4.19 **Use of dynamometer to measure power requirement of upland ploughing.**

4.10 TIME REQUIRED FOR DIFFERENT OPERATIONS

The actual time taken for any specific operation will depend on a unique set of circumstances, including the nature and condition of the soil, the efficiency of the implement and the physical condition and training of the animals. However, it is useful to have a guide as to what may be achieved under 'average' conditions, and *Table 4.2* gives a summary of practical experience from Njala. The table assumes 4-year old animals in good condition working medium soils, in 'average' conditions.

Table 4.2 - **WORK RATES FOR OX-CULTIVATION**

(Reasonable target figures for animals over 4 years old & in good condition)

Operation	*Work per unit area*		*Work per day*	*Work days per unit area*	
	hr/ha	*hr/ac*	*hr/day*	*day/ac*	*day/ha*
Upland ploughing	25	10	4-6	5-6	2-2.5
Upland harrowing (twice)	12	5	5	2.4	1
Seeding	12	5	6	2.0	0.8
Ridging (Light soil or ploughed land)	11	4.5	5	2.8	1.1
Weeding	9	4	5.5	1.6	0.6
Groundnut lifting	12	5	4	3.0	1.2
Swamp ploughing	33	13	3	11.0	4.5
Swamp harrowing (2-3 times)	20	8	3	6.7	2.7
Swamp levelling (2-3 times)	15	6	3.5	4.2	1.7