Appendices 1–4

Cultivation Trials:

Maize, Groundnuts, Cowpeas, Swamp Rice

1. Maize *(Zea mays)*

1.1 OBJECTIVES

- To compare the use of hand tools, ox-drawn implements and tractor-drawn implements for maize cultivation;
- to investigate the effectiveness of ox-drawn seeders and weeding tines in maize cultivation;
- to compare the effectiveness of two designs of ox-drawn toolbars.

1.2 EXPERIMENTAL DESIGN

Randomised block design with five treatments and three replications.

1.3 TREATMENTS

		Main power source			
No	*Sym-bol*	*Plough-ing & Harrow-ing*	*Seed-ing*	*Weed-ing*	*Equipment used*
1	HHH	Hand	Hand	Hand	Short handled hoe, string for row planting.
2	OHH	Oxen	Hand	Hand	6" Anglebar plough, triangular harrow, string for rows, hoe for weeding.
3	OOO	Oxen	Oxen	Oxen	6" Anglebar plough, triangular harrow, Super Eco seeder, Anglebar weeding tines, hand hoe.
4	OOO	Oxen	Oxen	Oxen	8" Sine Houe plough, triangular harrow, Super Eco seeder, Sine weeding tines, hand hoe.
5	THH	Tractor	Hand	Hand	Disc plough, disc harrow, string for rows, hand hoe.

1.4 COMMOM FEATURES

Site: Njala University College Farm.
Soil: Gravelly upland utisol or ferallitique of 'Njala' type (Van Vure *et al*, 1972).
Plot size: 45 m x 7.5 m.

Seed type: Western Yellow.
Spacing: 75 cm between rows, planted on flat.
Seeder Hand planting: 3 seeds/hole, 50 cm between holes.
Seeder: 16 hole disc giving 6½ seeds/metre.
Fertiliser: After (first) weeding: 100 kg/ha urea, plus 100 kg/ha superphos.

Operation Dates:

Ploughing	10th May 1980
Harrowing	15th May
Planting	16th May
Weeding	11th June
Harvesting	2nd September

1.5 RECORDED OBSERVATIONS

a) Time taken for each operation on each plot.
b) Plant population (number of maize plants per row and per plot).
c) Weed growth at 2, 4 and 6 weeks after weeding (5 random samples per plot. All weeds cut in sample area within rectangle 30 cm along row x 20 cm across mid-point of row AND within rectangle 30 cm along row x 55 cm between rows. Dry weight of stems and leaves recorded for each sample).
d) Yield weight of grain from each plot, 18 days after harvesting.
e) Implement performance: cultivation depth and subjective assessment recorded.

1.6 RESULTS

a) Time for operations

Mean operation time (manhours/ha)

Treatment		*Plough-ing*	*Harrow-ing*	*Plant-ing*	*Weed-ing*	*TOTAL*
1	HHH	375	320	149	360	1 204
2	OHH	46.6*	9.0	104	339	498
3	OOO	44.8*	7.9	18.0*	224†	295
4	OOO	46.6*	8.5	17.0*	201†	273
5	THH	1.6	2.1	134	302	440

Harvesting (mean all treatment) 112 manhr/ha.
Hand-shelling (mean all treatments) 140 manhr/ha.

* *Ox-team hours are half this, as 2 people were working with oxen.*
† *Weeding between rows, with oxen controlled by 2 people, and weeding along rows with short-handled hoe.*

b) Plant population

	1 HHH	2 OHH	3 OOO	4 OOO	5 THH	*Statistical analysis* ($p<0.05$)
Population: (No/meter along row)	3.7	4.0	5.3	4.6	3.7	NS

c) Weed growth

Between rows (dry weight of stems & leaves, g/m^2)

Treatment: Time for weeding	1 HHH	2 OHH	3 OOO	4 OOO	5 THH	*Statistical analysis* ($p<0.05$)
2 weeks	27.5	15.7	8.9	8.4	23.9	1,5>3,4
4 weeks	107	86.5	34.7	36.5	88.6	1,2,5>3,4
6 weeks	170	109	65.1	58.5	115	1>2,3,4,5 2>4 5>3,4

Along the rows (dry weight of stems and leaves, g/m^2)

Treatment:	1 HHH	2 OHH	2 OOO	4 OOO	5 THH	*Statistical analysis* ($p<0.05$)
Time for weeding						
2 weeks	62.1	37.2	22.7	17.8	44.7	1>3,4
4 weeks	208	105	72.9	75.7	93.1	1>2,3,4,5
6 weeks	232	118	156	122	158	NS

d) Yield

Treatment:	1 HHH	2 OHH	3 OOO	4 OOO	5 THH	*Statistical analysis*
Yield (kg grain/ha)	489	622	578	787	530	($p<0.05$) NS

e) Implement performance: working depth

Primary cultivation		*Weeding*	
Traditional hoe	6 cm	Traditional hoe	3-4 cm
6" Anglebar plough	10 cm	Anglebar tines	6-8 cm
8" Sine Houe plough	12 cm	Sine Houe tines	6-8 cm
Disc plough	15 cm		

1.7 DISCUSSION

a) Primary cultivation

Hand cultivation led to plant residues remaining on the surface and, following traditional practice, these were removed into piles. However, ploughing inverted the soil covering almost all plant residues. Both ox-ploughs inverted the soil well, but the disc plough led to relatively poor inversion and an uneven surface, although actual ploughing depth was greater.

The relatively poor quality of tractor ploughing was probably due to incorrect adjustments but, nevertheless, it was considered that it fairly represented the standard of upland ploughing normally achieved. A single passage of the triangular harrow, followed by a second passage with the harrow inverted produced a fine, even and relatively smooth seedbed in the gravelly upland soil. Hand cultivation followed by removal of plant residues produced a satisfactory seedbed, while tractor harrowing following tractor ploughing produced distinctly uneven results.

The time taken for primary cultivation ranged from 700 manhours/ha using hand tools to 55 manhrs/ha using ox-drawn implements and to only 3.7 manhrs/ha using a tractor. Thus, hand cultivation required about twelve times more human labour than ox-cultivation, and 180 times the labour required using tractor cultivation. The economic significance of these figures is discussed in Chapter 7.

b) Planting

In all treatments, seeds were planted in rows to facilitate weeding and fertiliser application. Using long strings to identify rows, hand planting at 50 cm intervals took 130 manhrs/ha while using an ox-drawn seeder required only 18 manhrs/ha, that is, 9 ox-team hours/ha.

On a perfect seedbed, the Super Eco seeder worked well and delivered seeds accurately to give a comparable, if slightly higher, overall seed rate. However, the seeder became easily clogged with plant debris,

indicating that particular care is required when preparing soil for this seeder.

c) Weeding

Weeding with a short-handled hoe resulted in many slightly disturbed plants on the surface and, in the humid conditions of the rainy season, many of these managed to survive and grow. One solution, sometimes used on local farms, would have been to gather the weeds into heaps, but this would have been very time consuming.

The ox-drawn weeder, on the other hand, not only cut or disturbed almost all the weeds between the rows, but also buried them quite effectively. Weed destruction was best when weeds were less than 5 cm high. In this trial, ox-weeding supplemented with hand hoe weeding required about 210 manhrs/ha, while hoe weeding alone required 330 manhrs/ha. However, the recorded time saving of 35% using oxen would have been much greater had the row spacing been 66 cm, which would have been ideal for the three 15 cm shares. In this trial, 75 cm rows were used, which required some hand weeding between the rows as well as along the rows.

d) Weed growth

Following the first weeding, weed growth was assessed at 2, 4 and 6 week intervals. Along the rows weed growth was similar for treatment 2, 3, 4 and 5, but greater for treatment 1 ($p<0.05$). This is illustrated in *Fig A1.1.* All treatments had similar hand weeding practices along the rows, so that the difference may be attributed to the different methods of primary cultivation. Hand cultivation led to greater weed regrowth than ox-ploughing treatments and the tractor ploughing.

Between the rows weeding was carried out by hand held hoes and ox-drawn tines. Treatments 3 and 4, which used ox-weeding had significantly ($p<0.05$) less weed regrowth than treatments using hand hoe weeding. Weed regrowth at six weeks was significantly ($p<0.05$) greater in Treatment 1, that had had hand primary cultivation, than the other treatments that had had ox-ploughing or tractor ploughing. This is clearly illustrated in *Fig A1.2.*

e) Ox-drawn implement performance

There were no differences between the treatment using the Sine Houe plough and weeder and the treatment using the Anglebar plough and weeder. Both types of equipment performed very well.

f) Crop yield

Overall yields were low and this is attributed primarily to the theft of fresh maize cobs. Statistically the yields did not differ. However, while the high co-efficient of variation of the crop yield made it difficult to distinguish between the yields statistically, it is interesting to note that the lowest yield came from the plots using hand cultivation, and the higher yields occurred in the plots using ox-ploughing.

In analysis of the economic costs of the different systems of cultivation, it may be assumed that the differing inputs resulted in comparable yields.

1.8 CONCLUSION

The trial provided data on the number of manhours required to cultivate maize in rows in an upland soil, using different cultivation systems to obtain comparable

yields. This is summarised in *Fig A1.3*. Weed growth was significantly ($p<0.05$) greater following hand hoe cultivation, than following ox-ploughing or tractor ploughing. Weed regrowth was significantly ($p<0.05$) lower following weeding with ox-drawn tines, than following weeding with a short handled hoe.

Fig A1.1 - MAIZE: GROWTH OF WEEDS ALONG ROWS AFTER ONE WEEDING

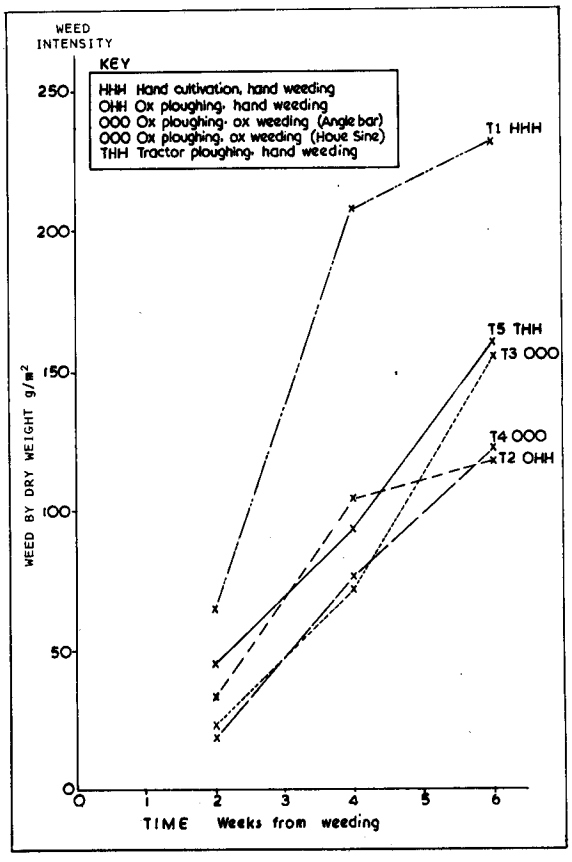


Fig A1-2 - MAIZE: GROWTH OF WEEDS BETWEEN ROWS AFTER ONE WEEDING

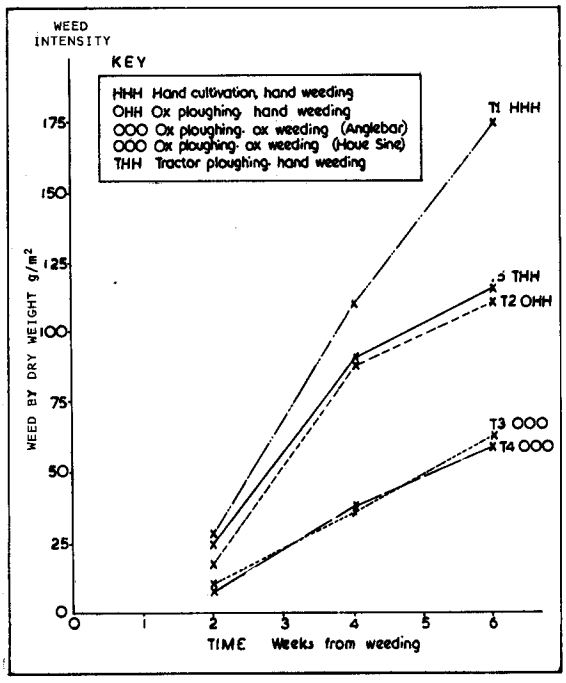
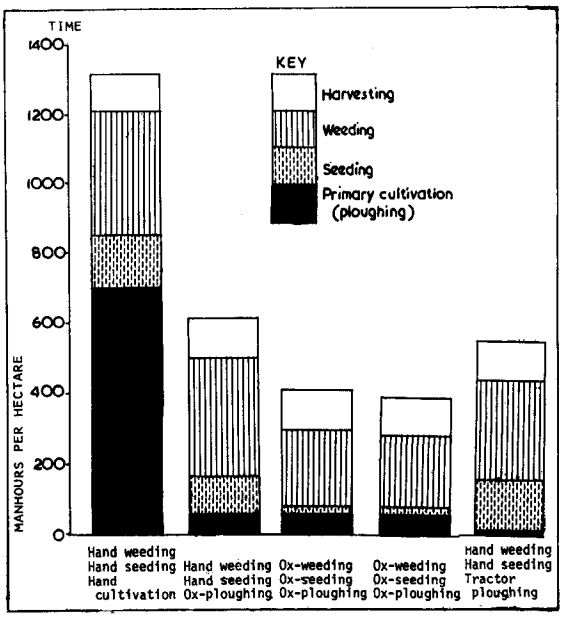


Fig A1.3 - MAIZE: LABOUR REQUIREMENTS FOR DIFFERENT SYSTEMS OF CULTIVATION



2. Groundnuts

(Arachis hypogaea)

1.2 OBJECTIVES - To compare the use of hand tools and ox-drawn equipment for groundnut cultivation.

2.2 EXPERIMENTAL DESIGNS Randomised block design with two treatments and three replications.

2.3 TREATMENTS

Treatment	*Cultivation system* Primary cultivation	Planting	Weeding	Harvesting	*Equipment used*
1 HHH	Hand	Hand	Hand	Hand	Short handled hoe.
2 OOO	Oxen	Oxen	Ox/Ha	Ox/Hand	Sine Houe 8" plough, triang. harrow, Super Eco seeder, Sine groundnut lifter.

Treatment 1 followed traditional techniques with seed planted irregularly, while Treatment 2 used line planting and line weeding.

2.4 COMMON FEATURES

Site: Njala University College Farm.
Soil: Gravelly upland utisol of 'Njala' type (Van Vure *et al*, 1972).
Plot size: 30 m x 5.5 m.
Seed type: Mares.
Seed rate: 10 seeds/m^2
Spacing: Treatment 1: seeds scattered by hand 10 seeds/m^2
Treatment 2: seeds planted in rows 66 cm apart using Super Eco seeder fitted with 24 hole plant.
Fertiliser: None.
Operation dates: Ploughing & harrowing, 15-20th May 1980
Planting 20th May
Weeding 17th June
Harvesting 27th August

2.5 RECORDED OBSERVATIONS

a) Time taken for each operation on each plot.
b) Plant population.
c) Weed intensity: 5 samples per plot, sample being all weeds in a rectangle 30 cm along plot x 66 cm across plot. Dry weight of stems and leaves recorded. Sampling 2, 4 and 6 weeks after weeding.
d) Yield: unshelled nuts weighed after 20 days of air drying.
e) Implement performance: working depth and subjective assessment of implement performance recorded.

2.6 RESULTS

a) Time *Mean operation time (manhrs/ha)*

Treatment	Primary Cultivation	Planting	Weeding	Harvesting	TOTAL
1 HHH	789	100	403	152	1 444
2 OOO	81*	24*	76*	52*	233

Manual picking of nuts from plants (mean for all treatments) 258 manhours/ha.

* *Figure includes use of 2 men for ox-ploughing, seeding and groundnut lifting, plus some additional manual work.*

Ox-team hours were: Primary cultivation 48 hr/ha. Planting 12 hr/ha. Weeding 10 hr/ha, Harvesting 12 hr/ha.

b) Plant population

Treatment	1 (HHH)	2 (OOO)	*Statistical analysis*
Population (plants/m^2)	2.5	3.0	($p<0.05$) NS

Overall density was low due to poor germination of seeds.

c) Weed intensity

Dry weight of stems and leaves (g/m^2)			
Treatment	1 (HHH)	2 (OOO)	*Statistical analysis* ($p<0.01$)
Time from weeding:			
2 weeks	13.8	4.0	NS
4 weeks	88.4	34.6	1>2
6 weeks	174.1	87.0	1>2

d) Yield

Treatment	1 (HHH)	2 (OOO)	($p<0.05$)
Kg dry unshelled nuts	322	344	NS

e) Implement performance

Ploughing depth:	8" Sine Houe	12 cm
	Short handle hoe	6 cm
Weeding depth:	3-tine weeder	6-8 cm
	Short handled hoe	3-4 cm

2.7 DISCUSSION

a) Primary cultivation

Hand cultivation followed by ox-ploughing and harrowing, both produced satisfactory seed-beds, but while plant debris was buried by ox-ploughing, it had to be collected into piles when cultivation was carried out by hand. Hand cultivation required 789 manhours per hectare, while ox-ploughing and harrowing required only 81 manhrs, a reduction of 90%.

b) Planting

Traditional planting methods with comparatively random spacing required 100 manhours per hectare, while the use of the Super Eco seeder drawn by oxen required 24 manhrs per hectare, a reduction of 76%. The use of the seeder with a 24-hole plate was considered satisfactory and an efficient method of planting seeds in lines on a good seed-bed. However, the seeder became easily clogged with plant debris indicating that primary cultivation has to be of good quality with good soil inversion to ensure satisfactory results from this seeder.

c) Weeding

The ox-drawn weeding tines were extremely efficient at destroying weeds between the rows. With three shares 15 cm wide, the weeder cultivated a strip about 45 cm wide between the 66 cm rows, but the soil movement at the sides effectively covered weeds even closer to the rows, and very little hand weeding was required after ox-weeding. Hand weeding was more shallow and weeds were more likely to survive hand weeding than ox-weeding. Hand weeding might have improved had weeds been piled up, but this would have required extra work and, at the same time, removed organic matter from the plots. Ox-weeding

took 76 manhrs/ha while hand weeding required five times more labour, at 403 manhrs/ha.

d) Weed growth

Weed regrowth was significantly ($p<0.01$) reduced by ox-weeding, compared with weeding with a short handled hoe. This is illustrated in *Fig A2.1.* Weed regrowth was high and it would have been preferable if a second weeding had been carried out.

e) Implement performance

The ox-plough, harrow, weeding tines and seeder performed satisfactorily, although the seeder was easily clogged by plant debris. The Sine Groundnut lifter achieved satisfactory results although it was difficult to control due to a large weed population at harvest time. Weeds clogged the lifter and prevented the efficient lifting of the groundnut plants. It was considered that a second weeding would have avoided the difficulties encountered. However, even with the problems of weed clogging the lifter, only 52 manhours per hectare were required to lift the groundnuts, a 66% reduction on the 152 manhours per hectare required when lifting was entirely manual.

f) Yield

Yields were very low at 333 kg/ha. There was no significant difference between the yields of the two treatments and so the inputs of the two systems can be compared on the assumption that the output would be the same.

2.8 CONCLUSION

The trial provided data on the labour requirements for cultivating groundnuts with hand labour or with ox-cultivation equipment in upland conditions. From the information obtained (summarised in *Fig A2.2*), it can be seen that for the same overall yield, hand cultivation required 1444 manhour/ha while ox-cultivation required only 233 manhrs/ha, a reduction of 84%. Using ox-drawn weeding tines led to a significant ($p<0.01$) reduction in weed regrowth compared with the hand cultivation system.

Fig A2.1 - GROUNDNUTS: GROWTH OF WEEDS AFTER ONE WEEDING

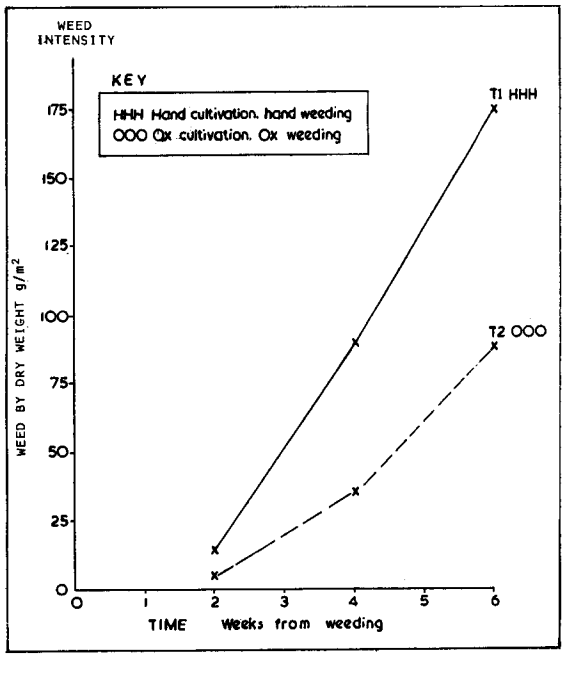
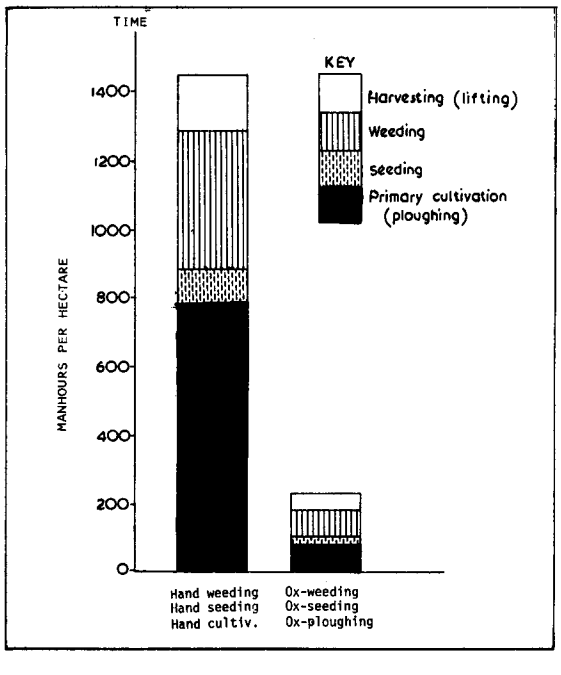


Fig A2.2 - GROUNDNUTS: LABOUR REQUIREMENTS FOR TWO SYSTEMS OF CULTIVATION



3. Cowpeas

(Vigna unguiculata)

3.1 OBJECTIVES

- To compare the use of hand tools and ox-drawn equipment for cowpea cultivation.
- To investigate the effectiveness of ox-drawn seeders and weeding tines in cowpea cultivation.

3.2 EXPERIMENTAL DESIGN

Randomised block design with four treatments and three replications.

3.3 TREATMENTS

No	*Symbol*	*Cultivation system*			*Equipment used*
		Primary Cultivation	*Planting*	*Weeding*	
1	HHH	Hand	Hand (not in rows)	Hand	Short handled hoe, Planting stick.
2	OHH	Oxen	Hand	Hand	Sine Houe 8" plough, triangular harrow, string for line planting, short handled hoe.
3	OHO	Oxen	Hand (in rows)	Oxen	Sine Houe 8" plough, triangular harrow, string for line planting, Sine 3-tine weeder.
4	OOO	Oxen	Oxen (in rows)	Oxen	Sine Houe 8" plough, triangular harrow, Super Eco seeder, Sine 3-tine weeder.

3.4 COMMON FEATURES

Site: Njala University College farm.

Soil: Gravelly upland utisol of 'Njala' type, (Van Vure *et al*, 1972).

Plot size: 36 m x 6 m.

Seed type: VII

Seed rate: 15.2 seeds/m^2.

Spacing: Treatment 1: Seeds scattered in plot, 1 seed per hole, 15.2 seeds/m^2.
Treatments 2 & 3: Rows 66 cm apart, 2 seeds per hole, 20 cm between holes.
Treatment 4: Super Eco seeder with 16-hole plate, giving 10 seeds/m, in rows 66 cm apart.

Plant population: All treatments thinned to give same population density, 6.4 plants/m^2.

Fertiliser: Basic slag 445 kg/ha, applied one day after ploughing.
Urea 67 kg/ha, applied one week after ploughing on day before planting.

Operation dates:

Ploughing	15th Sep 1980
Harrowing	22nd Sep
Planting	23rd Sep
Weeding	1st Nov
Harvesting	28th Nov 1980 - 15th Dec 1980

3.5 RECORDED OBSERVATIONS

a) Time taken for each operation on each plot.
b) Weed intensity after 5 weeks (day before weeding). All stems and leaves of weeds removed in 5 random stations in each plot. Sample size 30 cm (along row) by 66 cm (across row). Dry weight of weeds recorded.
c) Weed intensity 20 days after weeding. Five samples per plot, sample 30 cm (along row) by 46 cm (across middle of row). Dry weight of weed stems and leaves recorded.
d) Yield. Dry seeds weighed after threshing.
e) Implement performance. Cultivation depth and subjective assessment recorded.

3.6 RESULTS

a) Time: *Mean operation time (manhrs/ha)*

Treatment	*Ploughing*	*Harrowing*	*Planting*	*Weeding Between rows*	*Weeding Along rows*	*Total Weeding*	*TOTAL*
1 HHH	435	291	146	-	-	426	**1 298**
2 OHH	48*	14	290	-	-	401	**753**
3 OHO	48*	14	283	16	185	201	**546**
4 OOO	48*	14	31*	16*	173	189	**282**

* *Ox-team hours are half this as 2 people were working with the oxen.*

Harvesting: (mean all treatments), 604 manhrs/ha.
Threshing: (mean all treatments), 97 manhrs/ha.

b) Weed intensity:

Treatment	1 HHH	2 OHH	3 OHO	4 OOO	*Statistical analysis* ($p<0.01$)
Weeds between and on rows					NS
Day before weeding g/m^2 dry weight	47.4	42.4	37.2	44.1	NS
Weeds between rows: 20 days after weeding g/m^2 dry weight	-	19.2	10.8	17.0	NS

c) Yield

Treatment	1 HHH	2 OHH	3 OHO	4 OOO	*Statistical analysis* ($p<0.05$)
Kg dry seeds/ha	525	655	655	680	NS

d) Implement Performance

Ploughing depth:	8" Sine Houe	12 cm
	Short handled hoe	6 cm
Weeding depth:	3-tine weeder	6-8 cm
	Short handled hoe	3-4 cm

3.7 DISCUSSION

a) Primary cultivation

Primary cultivation and seedbed preparation appeared satisfactory in all cases. During cultivation by hand-held hoe, plant debris was collected and removed into piles; while using ox-ploughs most plant debris was buried. Using oxen required 62 manhrs/ha, while use of hand tools required 726 manhrs for primary cultivation, 12 times more than ox-cultivation.

b) Planting

The quickest method of planting was the use of the ox-drawn seeder (31 manhrs/ha), and this was five times as quick as random planting (146 manhrs/ha) and nine times as quick as hand planting in rows (285 manhrs/ha). However, the most even spacing was achieved when seeds were hand planted in rows. All methods were considered to give satisfactory results. The large time saving in using the ox-drawn seeder would be of particular advantage on large farms, where the capital cost of the seeder could be justified by large areas of operation.

c) Weeding

Weeding with a hand hoe tool took about 410 manhrs/ha and only a small time saving (7%) was achieved when weeding along rows compared with weeding more randomly spaced plants. Using oxen to weed between rows halved the overall time required for weeding to 196 manhrs/ha. Weeding with oxen is only possible if plants are row planted, but the additional time for row planting by hand is more than compensated by the savings in weeding time. The quality of weeding with ox-drawn tines appears better than hand hoeing, due to deeper cultivation and more effective burying of weeds.

d) Weed growth

Differences in weed growth between treatments were not statistically significant. However, it may be noted that weed growth was greatest in the plots that had been hand cultivated. Since in other trials also weed growth was greatest following hand cultivation, it is possible that greater replication of treatments might have shown that weed growth was significantly reduced by ox-cultivation. Overall weed growth was low, and much lower than weed growth in the maize trial carried out earlier in the growing season.

No statistically significant differences in weed growth were observed following different weeding systems. Weed growth was slightly greater following weeding by hoe, than following weeding with ox-drawn weeding tines. While this may be assumed to be attributable to random sampling, it may be noted that this is in line with other trials where weed regrowth was reduced by ox-drawn weeding tines.

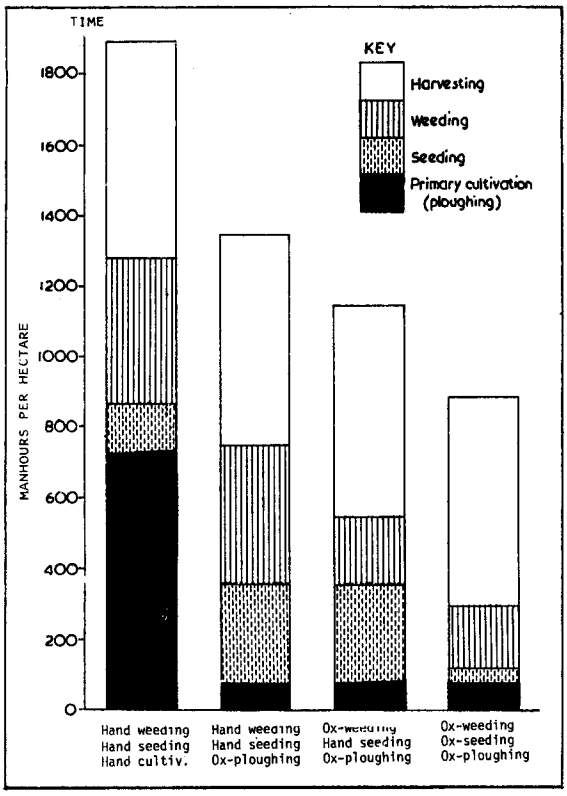
d) Yield

No statistically significant differences were observed in the yields of the four treatments. Thus, although yields following ox-ploughing were 20% higher than yields following primary cultivation using a short handled hoe, this could be attributable to random factors. In economic analyses the different cultivation systems may be compared on the assumption that yields will be equal.

3.8 CONCLUSIONS

The trial provided information on the work input required to produce comparable yields of cowpeas using different cultivation systems in gravelly upland soil. This information is summarised in *Fig A3.1* below. The number of manhours required to prepare the land, plant seeds and weed could be reduced by 92%, 79% and 52%, respectively using ox-drawn equipment. This indicated that cowpea cultivation systems using work oxen could be very attractive and the advantages of ox-cultivation are likely to increase with the area of cowpeas cultivated.

Fig A3.1 - COWPEAS: LABOUR REQUIREMENTS FOR DIFFERENT SYSTEMS OF CULTIVATION



4. Swamp Rice

(Oryza sativa)

4.1 OBJECTIVES

- To compare the use of hand tools with ox-drawn equipment for swamp rice production.
- To compare ox-cultivation carried out before flooding with ox-cultivation of flooded swamps.
- To compare two types of rice harvesting, harvest of whole plant and harvest of panicles alone.

4.2 EXPERIMENTAL DESIGN

Randomised block design with split plots involving three primary treatments, two sub-treatments and three replications.

4.3 TREATMENTS

Treatment	*Cultivation system*		*Equipment used*
	Ploughing	*Harrowing & Levelling*	
1 HHH	Hand (post flooding)	Hand (post flooding)	Long handled hoe
2 OOO	Oxen (pre flooding)	Oxen (post flooding)	Sine Houe with wheel, triangular harrow.
3 OOO	Oxen (post flooding)	Oxen (post flooding)	Sine Houe with skid, triangular harrow.

Sub treatments:
Each plot divided into two and, with randomised allocation, half was harvested with a small knife (panicles only) and half with a sickle (whole stem).

4.4 COMMON FEATURES

Site:	Njala University College farm.
Soil:	Poorly drained hydromorphic loamy soil of Pelewahun type (Van Vuie *et al*, 1972).
Swamp condition:	Semi developed swamp with bunds around levelled plots, but no control of water level. Flooding occurred naturally with rise in water table, and post-flooding operations were carried out in about 10 cm water. Swamp remained flooded from transplanting to harvest.
Plot size:	30 m x 3.4 m, with sub-plots 15 m x 3.4 m.
Seed variety:	BD2.
Transplanting:	After one month in nursery at 15-20 cm spacing, not in lines.
Fertiliser:	None.
Weeding:	None.
Operation dates:	Transplanting: 3rd Jul 1980 Bird-scaring: 20th Sep - 24th Oct Harvesting: 24th Oct

4.5 RECORDED OBSERVATIONS

a) Time taken for each operation on each plot.
b) Yield, weight of grain after threshing.
c) Implement performance: working depth and subjective assessment recorded.

4.6 RESULTS

a) Time for cultivation

Mean operation times (manhrs/ha)

Treatment		*Ploughing*	*Harrowing & Levelling*	*TOTAL*
1	HHH	417	150	567
2	OOO	62*	85*	147
3	OOO	72*	65*	137

* *Ox-team hours are half this as two people were working with the oxen.*

Brushing overgrown swamp before ploughing: 394 manhrs/ha
Transplanting (mean all treatments): 198 manhrs/ha

b) Time for harvesting

Mean operation times (manhrs/ha)

Treatment	*Harvesting*	*Threshing*	*TOTAL*
1 Harvesting panicle (foot threshing)	773	49	822
2 Harvesting whole stem (stick threshing)	320	65	385

c) Yield

Mean yields (kg/ha)

		Sub-plots		
Treatment		*Harvest panicle*	*Harvest stems*	*Means*
1	HHH	2 039	1 847	1 943
2	OOO	1 804	1 039	1 422
3	OOO	1 647	1 886	1 767
Means		1 830	1 591	1 711

Analysis of variance indicates that the differences in yields between the different treatments and the sub-treatments are not significant at the $p<0.05$ level.

d) Implement performance

Ploughing depth: Long handled hoe 7 cm
8" Sine Houe plough: 12 cm

4.7 DISCUSSION

a) Primary cultivation

Working in flooded conditions is not easy, but frequently necessary in semi-developed swamps. Hand hoeing in flooded conditions leads to much splashing of the workers and was very time-consuming, requiring 417 manhrs/ha for initial ploughing and 150 manhrs/ha for puddling and levelling. Using oxen in similar conditions required only 72 hours for ploughing and 65 hours for harrowing and levelling. This represents a reduction in mahhours per hectare of 76% compared with hand cultivation. The quality of ox-ploughing, harrowing and levelling in flooded conditions was very good, but the work was tiring for both the oxen and the operators.

The actual draught power requirement of the implements in flooded swamps was less than the comparable upland operations, but the problems of walking in flooded, muddy conditions appeared to make the flooded operations more tiring.

The quality of the ploughing in the swamp before flooding was good, and the work easier for oxen and operators, despite the higher draught requirement. However, in treatment 2 there was a period of one month between ploughing (pre-flooding) and harrowing (post-flooding) during which time weeds grew and, consequently, harrowing and levelling was more difficult than in Treatment 3, when harrowing followed ploughing by a matter of a few days.

The time-saving achieved by ploughing before flooding (62 hours for Treatment 2, pre-flooding, and 72 hours for Treatment 3, post-flooding), was removed by the extra difficulty of harrowing (85 hours for Treatment 2, 65 hours for Treatment 3). However, had the gap between ploughing and harrowing been shorter, it is likely that the difference would have been less. It was considered that the puddling effect of ox-trampling and ox-equipment was of better quality than that achieved by workers with hand tools.

b) Seeding and transplanting

In the three treatments discussed, similar transplanting was carried out, requiring 198 manhrs/ha. However, in the original experimental design two further treatments were planned and started. In both, the ploughing, harrowing and levelling were carried out before flooding, in preparation for seeding. One was to have been seeded by hand scattering, the other seeded with the Super Eco seeder. However, while on the day of harrowing and levelling, conditions seemed perf ct for sowing the following day, very heavy overnight rain left the plots under water the following morning; the plots remained flooded until after the harvest.

Thus, these treatments were abandoned and, from this, it is clear that such a system would be too risky for semi-developed swamps, as too early seeding might lead to serious weed competition; late seeding could be ruined by sudden flooding. Thus, seeding of swamp rice without water control would seem too risky to recommend.

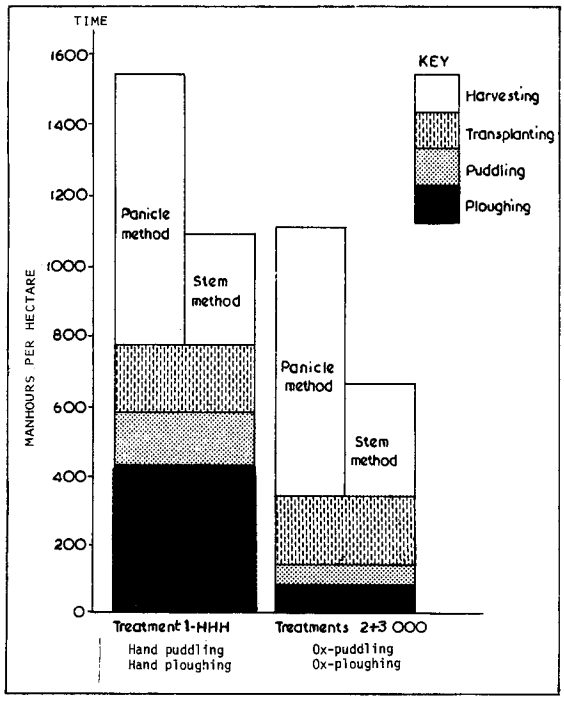
ploughed with oxen. Harvesting the whole stem of the plant required 320 manhrs/ha while harvesting each panicle required over twice the amount of labour (733 manhrs/ha). Differences in yield between the two systems were not statistically significant. Harvesting the whole stem is not only quicker, but it is also preferable in that it allows the swamp to be reploughed without further brushing; the rice straw is retrieved for feeding at a later date.
In the circumstances it would seem that harvesting of the whole stem has distinct advantages and, unless there are further contra-indications (perhaps social or storage factors could be important), this system is to be recommended.

d) Yield
Yields were low and there was a great deal of variation between the plots. Despite the presence of bird-scarers, losses from birds were considered high and it was observed that higher yields were harvested near the bird-scarers' platforms. It is therefore suggested that the large differences between the replications of each treatment may be attributable to non-random losses caused by birds. Differences between yields for the treatments and for the sub-treatments are not statistically significant. It is, therefore, assumed that the information on differences in inputs may be analysed on the basis of comparable output.

4.8 CONCLUSIONS

The trial produced data on the labour requirements for three systems of swamp rice production that may be assumed to give similar yields of grain. These are summarised in *Fig A4.1* below.

Fig A4.1 - SWAMP RICE: LABOUR REQUIREMENTS FOR DIFFERENT SYSTEMS OF CULTIVATION & HARVESTING



Using oxen required only 142 manhrs/ha for primary cultivation, while four times this labour (567 manhrs/ha) were required for primary cultivation by hand. Ox-ploughing was easier in pre-flooded conditions, but puddling was better following ploughing in flooded conditions. Where water control is possible it is

recommended that ploughing should be carried out in damp soil, but without surface water; flooding should immediately follow ploughing, so that harrowing and levelling should be done under flooded conditions. Harvesting the whole rice stem takes 320 manhrs/ha, half the time required for panicle harvesting (773 manhrs/ha) and has the advantage that the swamp can be reploughed without brushing.
