REPUBLIC OF ZAMBIA

MINISTRY OF AGRICULTURE FOOD AND FISHERIES

FINAL REPORT
ON
THE AGRICULTURAL VERIFICATION STUDY

APPENDIX

MARCH 1993

JAPAN INTERNATIONAL COOPERATION AGENCY

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APPENDIX I

BACKGROUND AND PROGRESS OF THE AGRICULTURAL VERIFICATION STUDY

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Table I.1.1 Population of the Provinces

	Population (1,000)	Density/km^2	% in Zambia	Growth Rate (%)	
				1969 - 1980	1980 - 1990
Central	725.6	7.7	9.3	3.2	3.5
Copperbelt	1,579.5	50.4	20.2	3.8	2.3
Eastern	973.8	14.1	12.4	2.2	4.0
Luapula	526.7	10.4	6.7	2.1	2.2
Lusaka	1,208.0	55.2	15.5	6.1	5.6
Northern	867.8	5.9	11.1	1.9	2.5
North Western	383.1	3.0	4.9	2.4	2.3
Southern	946.4	11.1	12.1	2.7	3.4
Western	607.5	4.8	7.8	1.5	2.2
Total	7,818.4	10.4	100.0	3.0	3.2

(Census, 1990)

Table I.1.2 Changes of Urban and Rural Populations

	1969	1980	1990
Urban areas (1,000)	1,192.1	2,258.5	3,285.8
Rural areas (1,000)	2,864.9	3,403.3	4,532.7
% of urban area in the country	29.4	39.9	42.0

(Zambia in Figures 1991)

Table I.1.3 Copper Export

	1970	1975	1980	1982	1984	1986	1988	1990
Total export (million kw)	706.8	518.0	1,029.0	950.5	1,199.4	5,366.5	9,786.2	39,143.3
Copper export (million kw)	681.4	472.0	870.6	855.4	1,031.2	4,428.6	8,339.6	33,733.6
% of copper in the total	96.4	91.1	84.6	90.0	86.0	82.5	85.2	86.2

(Monthly Digest of Statistics)

Table I.1.4 Index Number of Consumer Prices

	1985	1986	1987	1988	1989	1990 (Jan.)	1990 (June)	1991 (Jan.)	1991 (June)	1991 (Dec.)
High income group	100	161	250	376	847	1,239	1,568	2,587	3,057	4,636
Low income group	100	154	224	347	794	1,198	1,517	2,477	3,208	4,987

(Consumer Price News 1991)

Table I.1.5 Annualized Inflation (%)

	1985	1986	1987	1988	1989	1990	1991
Total	58.7	35.2	48.0	57.2	153.2	106.8	111.1
High income	61.6	43.9	50.6	52.6	159.1	108.3	88.9
Low ncome	58.3	33.9	47.5	57.9	152.4	106.6	114.5

(Consumer Price News 1991)

Table I.1.6 Ratio of Commercialized Volume to Total Production of the Main Crops (%)

	1986	1987	1988	1989	1990
Maize	77.6	61.7	69.4	66.1	58.5
Sunflower	87.2	41.0	76.8	49.4	93.4
Soybeans	81.4	17.4	6.8	0.8	94.2
Groundnuts	34.5	3.7	1.7	0.5	1.7
Rice	49.7	44.4	59.3	40.0	59.5
M. Beans	9.6	7.0	0.5	1.9	3.0
Sorghum	2.0	1.3	7.5	1.0	5.1
Cotton	100.0	100.0	100.0	97.9	100.0
V. Tobacco	100.0	100.0	100.0	100.0	100.0
B. Tobacco	99.6	100.0	100.0	99.6	100.0
Millet	2.5	0.7	1.9	1.4	1.0
Wheat	–	96.0	80.8		

(Calculated from Official Crop Production and Sales Data)

Table I.1.7 Planted Area of Main Crops in the Provinces (1990)

(ha)

		Central	Copper-belt	Eastern	Luapula	Lusaka	Northern	North-western	Southern	Western	Total
Maize	Area	103,756	22,025	261,782	16,532	25,535	45,149	16,498	232,826	39,175	763,277
	% in the Country	13.6	2.9	34.2	2.2	3.3	5.9	2.2	30.5	5.1	100
Sunflower	Area	6,993	76	12,219	111	2,972	101	67	21,684	66	44,289
	% in the Country	15.8	0.2	27.6	0.3	6.7	0.2	0.1	49.0	0.1	100
Soybeans	Area	7,030	3,273	7,209	985	1,405	2,817	2,983	3,984	129	29,814
	% in the Country	23.6	11.0	24.2	3.3	4.7	9.4	10.0	13.4	0.4	100
Groundnuts	Area	9,453	2,663	20,816	6,989	903	19,543	1,384	15,963	2,729	80,443
	% in the Country	11.8	3.3	25.9	8.7	1.1	24.3	1.7	19.8	3.4	100
Rice	Area	95	59	1,509	493	55	3,423	188	–	3,806	9,628
	% in the Country	1.0	0.6	15.7	5.1	0.6	35.6	2.0		39.5	100
M. Beans	Area	2,071	203	722	4,102	7	15,585	3,485	69	192	26,435
	% in the Country	7.8	0.8	2.7	15.5	0	59.0	13.2	0.3	0.7	100
Sorghum	Area	4,968	7,312	7,261	1,023	1,358	744	6,084	12,366	7,350	48,465
	% in the Country	10.3	15.1	15.0	2.1	2.8	1.5	12.6	25.5	15.2	100
Cotton	Area	24,570	500	14,833	50	2,295	68	53	21,251	416	64,036
	% in the Country	38.4	0.8	23.2	0.1	3.6	0.1	0.1	33.2	0.6	100
V. Tobacco	Area	933	180	597	2	488	3.0	25	1,195	138	3,588
	% in the Country	26.0	5.0	16.6	0.1	13.6	0.9	0.7	33.3	3.8	100
B. Tobacco	Area	67	38	1,199	30	40	41	20	47	1	1,483
	% in the Country	4.5	2.6	80.8	2.0	2.7	2.8	1.3	3.2	0.1	100
Millet	Area	5,233	70	5,754	12,709	0	15,053	1,060	7,076	11,914	58,868
	% in the Country	8.9	0.1	9.8	21.6	0	25.6	1.8	12.0	20.2	100
Cassava	Area	1,770	176	0	45,173	0	20,298	14,629	56	21,057	103,159
	% in the Country	1.7	0.2	0	43.8	0	19.7	14.2	0.1	20.4	100
Wheat (Rainfed)	Area	1	0	0	0	0	352	3	0	0	352
	% in the Country	0.3	0	0	0	0	98.9	0.8	0	0	100
* Wheat (Irrigated)	Area	585	700	110	–	3,213	–	–	2,317	–	6,925
	% in the Country	8.4	10.1	1.6		46.4			33.5		100

(Official Crop Production and Sales Data 1990)

(* Agr. Statistics Bulletin 1988)

Table I.1.8 Farm Units and Farm Population by Province and by Farm Level (1980)

Province	Commercial Farms								Traditional Farms		Total		% of Number of Commercial Farms
	Large scale (>40 ha)		Medium scale (40 - 10 ha)		Small scale (10 - ha)		Sub - Total						
	Farms	Pop. (1,000)	Farms	Pop. (1,000)	Farms	Pop. (1,000)	Farms	Pop. (1,000)	Farms	Pop. (1,000)	Farms	Pop. (1,000)	
Southern	320	160	8,000	76.0	49,900	374.1	58,220	466.1	7,500	33.9	65,720	500	88.6
Central	300	15.2	7,630	72.5	21,400	160.5	29,330	248.2	18,400	82.8	47,730	331	61.4
Lusaka	90	4.3	1,910	18.1	4,300	32.3	6,300	54.7	13,400	60.3	19,700	115	32.0
Copperbelt	-	-	490	4.7	2,000	14.9	2,490	19.6	17,900	80.4	20,390	100	12.2
Eastern	20	1.0	3,100	29.5	27,000	202.7	30,120	233.2	80,900	363.8	111,020	597	27.1
Western	-	-	-	-	5,450	40.8	5,450	40.8	85,400	384.2	90,850	425	6.0
North Western	-	-	80	0.8	2,900	21.9	2,980	22.7	53,600	241.3	56,580	264	5.3
Luapla	-	-	50	0.5	2,050	15.3	2,100	18.8	73,600	331.2	75,700	347	2.8
Northern		-	90	0.8	7,400	55.5	7,490	56.3	111,900	503.7	119,360	560	6.3
Total	730	36.5	21,350	202.9	122,400	918.0	144,480	1,157.4	462,600	2,081.6	607,080	3,239	23.8
%	0.1	1.1	3.5	6.3	20.2	28.3	23.8	35.7	76.2	64.3	100	100	

(Agricultural Base - Line Data for Planning, 1983)

Table I.2.1 Population in the Districts of the Western Province

	Area (km^2)	1980			1990		
		Population	% of the Province	Density/ km^2	Population	% of the Province	Density/ km^2
Karabo	17,526	97,933	20.1	5.6	101,410	16.7	5.8
kaoma	23,315	70,149	14.4	3.0	112,747	18.6	4.8
Lukulu	16,291	42,996	8.8	2.8	51,016	8.4	3.1
Mongu	10,075	116,888	24.0	11.4	142,213	23.4	14.1
Senanga	29,907	101,662	20.8	3.4	135,210	22.3	4.5
Sesheke	29,272	58,360	12.0	2.0	64,901	10.7	2.2
Total Western Provinces	126,386	487,988	100	3.9	607,497	100	4.8
Total Zambia	753,000	5,662,000		7.5	7,184,000		10.4
Western/ Zambia (%)	16.8	8.6		52.0	8.5		46.2

(Provincial Medium Term Development Plan 1991 - 1996)

Table I.2.2 Planted Area of Main Crops in the Districts of the Western Province (1990)

		Karabo	Kaoma	Lukulu	Mongu	Senanga	Sesheke	Total Western
Maize	Area (ha)	3,519	11,078	2,191	4,828	6,764	11,013	39,389
	Production (t)	1,496	25,629	1,818	2,083	2,447	4,148	37,621
Sunflower	Area (ha)	10	37	1	0	6	8	62
	Production (t)	3	6	0.3	0	0.9	1.5	12
Soybeans	Area (ha)	4	123	2	0	0	0	129
	Production (t)	0.3	14	0.7	0	0	0	15
Groundnuts	Area (ha)	16	425	68	31	62	1,194	1,796
	Production (t)	8	88	21	2.4	12	152	283
Rice	Area (ha)	1,604	315	298	3,713	288	15	6,233
	Production (t)	805	166	250	2,549	319	7	4,095
M. Beans	Area (ha)	172	0	20	0	0	0	192
	Production (t)	108	0	5	0	0	0	113
Sorghum	Area (ha)	1,447	569	247	524	1,829	2,622	7,238
	Production (t)	517	205	189	194	510	573	2,188
Cotton	Area (ha)	0	428	7	0	50	0	485
	Production (t)	0	140	2.8	0	14.7	0	157.5
Cassava	Area (ha)	3,525	4,689	3,531	8,005	1,121	0	20,869
	Production (t)	1,569	4,689	1,585	3,634	371	0	11,848
Millet	Area (ha)	1,620	1,845	1,093	1,799	2,951	5,100	14,408
	Production (t)	729	498	1,136	584	905	590	4,442

(Crop Forecast 1990)

Table I.2.3 Commercialized % of Main Crops in the WesternProvince (%)

	Maize	Rice	Sorghum	Millet	Cassava
1989	51.3	35.0	0.8	7.0	0
1990 (Estimated)	54.2	52.3	1.9	6.0	0

(Crop Forecast 1990)

Table I.2.4 Cereal Self-sufficiency Levels per District in % (Average of 1988 - 1990)

		Karabo	Kaoma	Lukulu	Mongu	Senanga	Sesheke	Total
Production (t)	Maize	1,719	24,214	2,233	2,233	2,644	5,730	38,773
	Rice	195	69	67	687	70	4	1,092
	Sorghum	507	167	211	145	676	1,040	2,746
	Millet	804	403	925	558	992	647	4,329
	Cassava	2,106	4,862	5,168	8,660	1,008	710	22,514
	Total	5,331	29,715	8,604	12,283	5,390	8,131	69,454
Population		103,324	89,449	51,673	139,391	115,762	64,412	564,011
Total consumption (t) (200 kg/year/person)		20,665	17,890	10,335	28,878	23,152	12,882	112,802
Self-sufficiency level (%)		26	166	83	44	23	63	62

(Provincial Medium Term Development Plan 1991 - 1996)

Table I.2.5 Cattle Number in the Districts of the Western Province (1989)

	Heads (1,000)	% in the Province
Kaoma	21.9	4.2
Karabo	105.5	20.6
Lukulu	66.5	13.0
Mongu	90.2	17.6
Senanga	158.9	31.0
Sesheke	69.9	13.6
Total	512.9	100.0

(Provincial Medium Term Development Plan 1991 - 1996)

Table I.2.6 Number of Draft Cattle, Farmers Population, and Area under Crops per District in the Western Province (1990)

	Draft Cattle (Heads)	Farmers population	* Normaly planted area (ha)	Draft cattle number/Farmers population (Heads/person)	Draft cattle number/Plowed area (Heads/ha)	Planted area per one farmer
Karabo	19,329	12,112	12,152	1.6	1.6	1.0
Kaoma	4,698	9,310	22,726	0.5	0.2	2.4
Lukulu	7,800	4,527	10,558	1.7	0.7	2.3
Mongu	16,106	13,792	19,935	1.2	0.8	1.4
Senanga	24,429	7,577	13,703	3.5	1.9	1.8
Sesheke	12,942	6,839	17,785	1.9	0.7	2.6
Total	87,304	54,157	96,259	1.6	0.9	1.8

Note: * Area planted (Plowed) normally; unplowed fields planted mainly with cassava or millet are excluded.

(Provincial Medium Term Development Plan 1991 - 1996)

Table I.2.7 Planted Area of Main Crops by Types of Farms in the Western Province (1990)

	Maize		Rice		Sorghum		Millet		Cassava	
	No. of farms	Area (ha)	No. of farms	Area (ha)	No. of farms	Area (ha)	No. of farms	Area (ha)	No. of farms	Area (ha)
Commercial farms	37	626	1	9	3	12	5	27	0	0
Institutional farms	192	484	59	74	11	12	18	31	29	19
Emergent farms	2,009	7,869	381	852	727	953	860	1,233	1,068	1,307
Small scale farms	34,980	30,410	6,350	5,292	8,461	6,258	12,589	13,120	21,206	19,543
Total	37,218	39,389	6,791	6,227	9,202	7,235	13,472	14,411	22,303	20,869
% of small scale farms	94.0	77.2	93.5	85.0	92.0	86.5	93.4	91.0	95.1	93.6

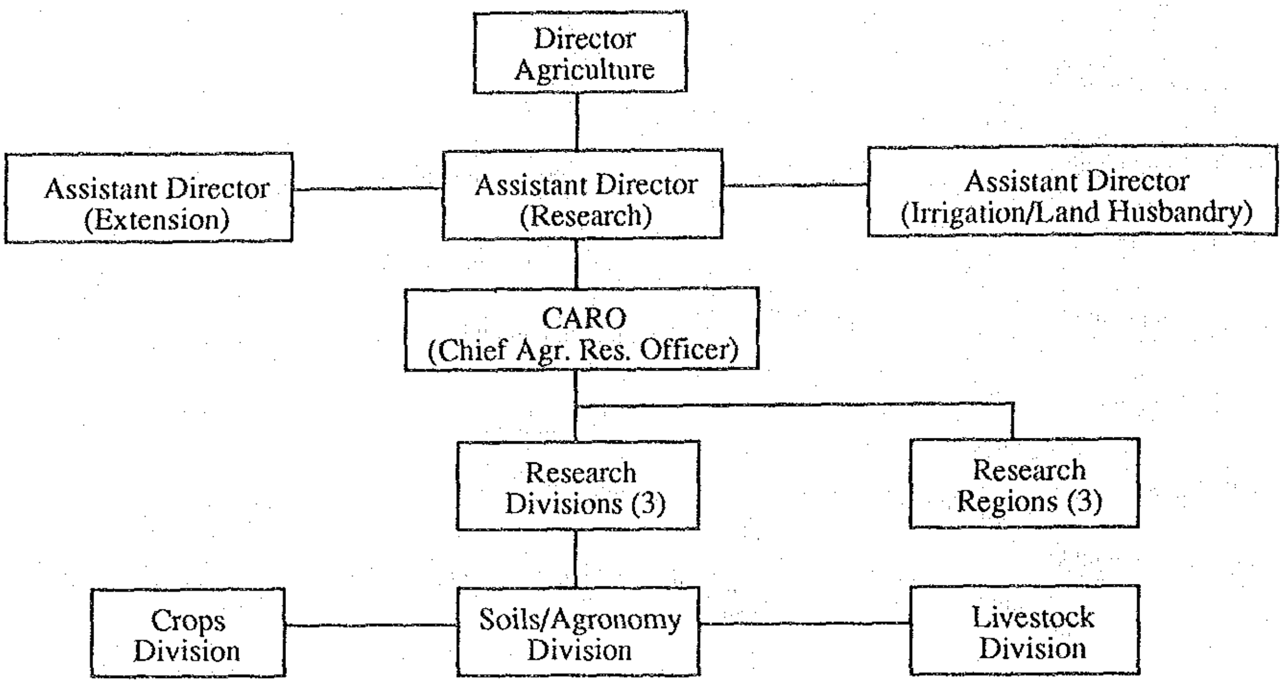
(Crop Forecast 1990)

Table I.3.1 Planted Area of Main Crops by Types of Farms in the Mongu District

Type of farms	Maize		Rice		Sorghum		Millet		Cassava	
	No. of farms	Area	No. of farms	Area	No. of farms	Area	No. of farms	Area	No. of farms	Area
Commercial	-	-	-	-	-	-	-	-	-	-
Institutional	33	26	29	45	-	-	1	2	9	10
Emergent	335	458	259	542	89	65	114	142	277	594
Small scale	8,767	4,341	4,167	3,126	811	459	2,406	1,655	7,650	7,401
Total	9,135	4,825	4,455	3,713	900	524	2,521	1,799	7,936	8,005
% of small scale	96.0	90.0	93.5	84.2	90.0	87.6	95.4	92.0	96.4	92.5

(Crop Forecast 1990)

Research Organization
(Source: Research Action Plan, 1991)



Extension Organization
(Source: Extension Action Plan, 1991)

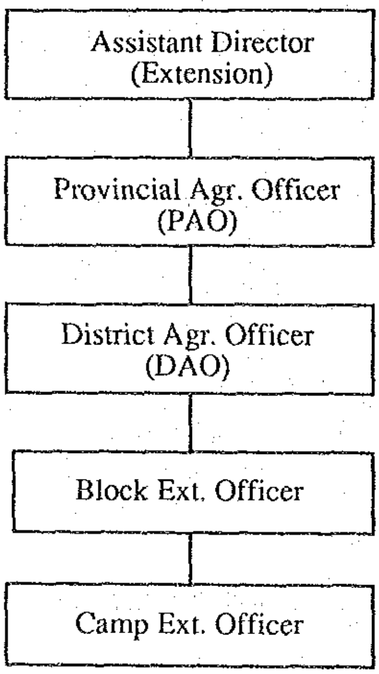


Figure I.1.1 Research and Extension Organization

APPENDIX II

CROP PRODUCTION TECHNOLOGY

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II. CROP PRODUCTION TECHNOLOGY

II.1 Component Technology

II.1.1 Paddy Rice Cultivation

(1) Varietal trial over different sowing date

[Namushakende farm in 1988/89]

1) Materials and methods

Test field: Namushakende JICA/AVS field

Tested variety:

1. IR-54	11. ITA 225
2. IR-24632-43-2	12. ITA 222
3. IR8067-41-IE-PI	13. ITA 306
4. C1158-3	14. CHINA 998
5. P1369-4-16M-2M-4	15. MALAWI FAYA
6. P2023-F4-53-1B-1B	16. RP-1082-24-2-2-2
7. IR8192-166-2-2-3	17. BURMA
8. BG374-1	18. Angola Crystal
9. KALEMBWE	19. XIANG ZHOU 5
10. ANGOLA 2	20. ITA 234

Date of transplanting & field:

Dec. 19-22/88	M-1-1
Jan. 3-4/89	M-1-2
Jan. 16/89	M-2-1
Jan. 30/89	M-2-2
Feb. 15/89	M-3-1

Planting density:

Row space; 30 cm, Hill space; 15 cm, 2 seedlings/hill

Fertilizer:

Basal dressing	:	D'mix 150 kg/ha before puddling
Top dressing 1	:	Urea 40 kg/ha at tillering stage
Top dressing 2	:	V'mix 135 kg/ha at tillering stage
Top dressing 3	:	Urea 40 kg/ha at meiosis stage

2) Summary

The results on grain yields and components for the tested varieties are shown in Table II.1.1.1. The data for the 4th and 5th sowing date were cancelled due to poor growth. The pooled mean of the grain yield in each sowing date decreased from 347 gm/m^2, 1st sowing (Nov. 15), to 319.4 gm/m^2, 3rd sowing (Dec. 15), when the sowing date shifted.

The highest yield in the 1st sowing date group was 542.5 gm/m^2 from the local variety, Kalembwe, followed by 530 gm/m^2 from the improved variety, P2023. In the 2nd sowing date group, the local variety Angola crystal yielded 624.3 gm/m^2, followed by the variety Xiang Zhou 5 which yielded 519.3 gm/m^2. Among yield performance in the 3rd sowing date group, C1158 was the highest with 486.1 gm/m^2 followed by ITA225 with 467.1 gm/m^2.

[Namushakende farm in 1989/90]

1) Objectives

Trials were aimed at selecting optimum sowing dates and optimum early or late maturing varieties of rice that will be associated with upland crops in a double cropping system.

2) Methods and materials

a) Early maturing varieties

Farm: Namushakende (M-2-2, M-3-1)

Experimental design:	Split plot arrangement with 3 replications, 2.1 m x 9.5 m = 19.95 m^2/variety	
Varieties:	IR 8067, C1158, Kalembwe, Angola 2, ITA 222, Xiang Zhou 5, ITA 234	
Sowing dates:	Nov/5, Nov/20, Dec/5	
Seed rate and spacing:	60 kg/ha, drilling on dry soil with 30 cm in between rows	
Fertilizer dosage:	Lime; 1.5 t/ha	
	Basal dressing;	D'mix 250 kg/ha after emergence
	Top dressing;	Urea 20 kg/ha at tillering
		Urea 20 kg/ha at meiosis
		Urea 50 kg/ha at booting

b) Late maturing varieties

Farm:	Namushakende (M-4)	
Experimental design:	Split plot arrangement with 3 replications. 2.4 m x 9.6 m = 23 m^2/variety	
Variety tested:	P1369, P2023, IR8192, ITA222, Burma, Supa	
Sowing dates:	Nov/15, Nov/30, Dec/15	
Seed rate and spacing:	60 kg/ha via selection with water, drilling on dry bed with 30 cm apart from row	
Fertilizer dosage:	Lime; 1.5 t/ha via broadcasting method	
	Basal dressing;	D'mix 300 kg/ha after emergence
	Top dressing;	Urea 20 kg/ha at tillering
		50 kg/ha at meiosis
		V'mix 200 kg/ha at meiosis

3) Summary

a) Early maturing varieties

Yields and components of all tested varieties are shown in Table II.1.1.2. The pooled mean of the grain yield was 327.1 gm/m^2 for the November 5 sown varieties, 347.8 gm/m^2 for the November 20 and 399.8 gm/m^2 for the December 5, with an increase is yield toward the late sowing dates.

This tendency might be explained by the water stress imposed to the group sown in the beginning of rainy season marked by scarce precipitations and the absence of this constraint for the group sown later in a period with more regular rains.

The highest yield in the 1st sowing group was 401.3 gm/m^2 for ITA234, while the lowest was 208.9 gm/m^2 for the local variety, Kalembwe. In the 2nd sowing group, ITA225 yielded the highest with 424.9 gm/m^2 and ITA234 the highest in the 3rd sowing group with 499.8 gm/m^2. Kalembwe yielded the lowest in either of these groups with 218.1 gm/m^2 and 284.2 gm/m^2 respectively.

The statistical analysis showed a significant difference among sowing dates and varieties at the 5% and 1% level respectively; however, no interaction between varieties and sowing date was detected. As early maturing varieties, ITA225, and ITA234 were relatively high yielding, and C1158, IR8067 were next. Xiang Zhou 5 yielded very high in the first year but relatively low this year.

b) Late maturing type

Yields and components of all tested varieties are shown in Table II.1.1.3. The pooled mean of the grain yield for the 1st to the 3rd sowing date was 290.0, 209.9 and 193.5 gm/m^2, respectively, indicating a decreasing trend toward the late sowing date. The highest yield in the 1st sowing group was 469 gm/m^2 from ITA222, 354.3, and 320.6 gm/m^2 from P1369 in the 2nd and 3rd sowing groups, respectively. The local variety, Supa yielded the lowest among the tested varieties with yields ranging between 178.2, 95, and 74.1 gm/m^2 for the 3 periods considered.

This yield level was far from its original performance. As a result of the analysis of variance, a significant difference was detected among varieties at the 5% level. But no significant differences among sowing dates as well as no interaction between varieties and sowing date were detected.

Generally yield performance of the late maturing varieties was relatively low, except for P1369 and IR8192. After further investigations based on this trial, ITA222 was classified as a group of the early maturing varieties.

[Lealui farm in 1989/90]

1) Objectives

Trials were aimed at examining an optimal deep water variety with optimal sowing date in sandy soil under annual flooding condition.

2) Materials and methods:

Farm:	Lealui (N-3-2)	
Experimental design:	Split plot arrangement with 3 replications, 3.6 m x 10 m = 36 m^2/variety	
Varieties:	Malawi faya, Burma, Supa, Angola crystal	
Sowing date:	December 1, 16	
Seed rate:	60 kg/ha via selection with water, drilling on dry bed with 30 cm in between rows	
Fertilizer application:	Basal dressing;	D'mix 200 kg/ha at emergence
	Top dressing;	D'mix 100 kg/ha at tillering
		Urea 50 kg/ha at meiosis

3) Summary

Yield and components of all entries are shown in Table II.1.1.4. The pooled mean value of the grain yield in the 1st and 2nd sowing groups was 237.6 gm/m^2 and 250.5 gm/m^2, with yield increasing toward the late sowing date. This tendency might be due to the mitigation of drought stress when the sowing dates are late and coincide with the period of more rain. But no significance was statistically detected. The overall yield levels were low with around 2 t/ha and the highest yield in the 1st and 2nd sowing groups amounted respectively to 256.2 gm/m^2 from the Malawi faya and 299.5 gm/m^2 from the Angola crystal. On the other hand, the lowest yield in the 1st and 2nd sowing groups were 225.5 gm/m^2, and 217.1 gm/m^2 respectively from the Burma. No significant differences among the varieties, sowing dates and interaction of both factors were detected statistically due to drought effect.

[Namushakende farm in 1990/91]

1) Materials and methods

a) Early maturing type

Field:	Namushakende, M-2-2/1,000 m^2
Experimental design:	Split plot design with 3 replications
Tested varieties:	IR8067, C1158, Angola crystal, ITA225, Xiang Zhou 5, ITA234, ITA222
Sowing date:	1st-Nov. 15 by direct sowing on dry bed in drill 2nd-Jan. 4 by direct sowing on flooded bed in drill.
Seed rate:	60 kg/ha via screened with water, 30 cm in between rows
Fertilizer application:	Lime 1.5 t/ha via broadcasting D'mix 250 kg/ha at emergence Urea 50 + 50 kg/ha at tillering and meiosis stage

b) Late maturing type

Field:	Namushakende, E-5-2 / 1,000 m^2
Experimental design:	Split plot design with 3 replications
Tested varieties:	P1369, P2023, IR8192, Burma, BG374-1
Sowing date:	1st-Dec. 10 by direct sowing on dry soil 2nd-Jan. 5 by direct sowing on wet soil
Seed rate:	60 kg/ha via selection with water, 30 cm row spacing
Fertilizer application:	Lime 1.5 t/ha, via broadcasting Basal dressing, D'mix 300 kg/ha at emergence Top dressing, Urea 50 + 50 kg/ha at tillering and meiosis stage

2) Summary

a) Early maturing varieties

Table II.1.1.5 shows the result of the tested varieties on the grain yields and components. The data of the 2nd sowing date is shown as a reference due to poor emergence. The pooled mean of the grain yield in the 1st sowing group (Dec. 10 sown) was 414 gm/m^2. The highest yield was 586.5 gm/m^2 from ITA222 and the lowest 331.8 gm/m^2 from Angola 2, resulting similarly in high yield level for the ITA strains last year. From this result, the ITA strains appear to be promising varieties of the short culm type which are not soil type-specific.

The ripening percentage of all tested varieties was relatively low amounting to 77.9% or less than 80% but appeared from past observations to increase under more application of N fertilizer as a top dressing. The 1,000 grains weight of ITA 222 was the largest among the ITA strains, and its pooled mean of panicle numbers/m^2 exceeded 300. But C1158, a high tillering variety was more than 600/m^2 which assumed that available phosphate was enough to allow tillering in the test field. No significant difference among the tested varieties was detected, but positive correlations was observed between grain yield and yield components.

From these results, it seems that nitrogen application is more effective than a basal dressing as a top dreesing.

b) Late maturing varieties

The result on the grain yields and components of the tested varieties is shown in Table II.1.1.6. The pooled mean of the grain yield in the 1st and 2nd sowing groups was 354.5 and 304.2 gm/m^2 respectively, with 14% decrease when the sowing date was delayed. But this decrease was dependent on varieties, and both P2023/IR8192 varieties showed a severe decrease, which was significant at the 5% level. This implies that both varieties had better be sown at least by early to mid December or a severe decrease in yield might occur if sowing is delayed until the next year. Following these two varieties the yield of P1369 was also severely affected (significant at 10% level). In the 1st sown group, only P1369 and P2023 yields exceeded 400 gm/m^2 and the lowest yielding variety was Burma with 237.4 gm/m^2. A good cultural practice for rice production in the Sishanjo soil should be the one stressing on a topdressing-based N application method.

[Lealui farm in 1990/91]

1) Materials and methods

Field:	Lealui (S-2-2/1,000 m^2)
Experimental design:	Split-plot design with 3 replications
Tested variety:	Angola crystal, Supa, Malawi Faya, Burma
Seed rate:	60 kg/ha via selection with water
Spacing:	30 cm in between rows
Sowing date:	1st sowing/Dec. 7, 2nd sowing/Jan. 7

Fertilizer:	Basal dressing, D'mix 200 kg/ha at emergence and initial tillering stage by split application Top dressing, Urea 50 kg/ha at tillering before flooding

2) Summary

Table II.1.1.7 shows the result on the grain yields and components of the tested varieties. The pooled mean yield of each sowing date group was 274.7 and 208.9 gm/m^2 respectively, indicating that one month delay in sowing reduced the pooled mean yield by 31.5 %. The degree of yield reduction varied with varieties, and Malawi faya and Angola crystal showed the biggest decrease, and this was statistically significant at the 5% level.

On the other hand, only the yield of Burma increased probably due to soil heterogeneity within the experimental plot. In the 1st sowing group, Angola crystal recorded the highest yield of 334.9 gm/m^2, and Supa the lowest of 197.7 gm/m^2, in the following ranking order: Angola crystal > Malawi faya > Burma > Supa. While in the 2nd sowing group, Burma has the highest yield of 296.2 gm/m^2, followed by Malawi faya > Angola crystal > Supa. The yield components were identically reduced when the sowing date was delayed but the 1,000 grain weight was constant.

[Namushakende farm in 1991/92]

1) Materials and methods

a) Early maturing varieties

Field:	Namushakende, M-2-2/1,000 m^2
Experimental design:	Split plot design with 3 replications
Tested varieties:	IR8067, C1158, Angola 2, ITA225, Xiang Zhou 5, ITA234, ITA222
Sowing date:	1st/Oct. 25 by direct sowing on dry bed in drill 2nd/Nov. 28 by direct sowing on wet bed in drill.

Seed rate:	60 kg/ha screened with water, 30 cm in between rows
Fertilizer application:	Lime 1.5 t/ha by broadcasting D'mix 250 kg/ha at emergence Urea 50 + 50 kg/ha at tillering and meiosis stage

b) Late maturing type

Field:	Namushakende, E-5-2 (1,000 m^2)
Experimental design:	Split plot design with 3 replications
Tested cultivars:	P1369, P2023, IR8192, Burma, BG374-1
Sowing date:	1st/Oct. 25 by direct sowing on dry bed 2nd/Nov. 28 by direct sowing on wet bed
Seed rate:	60 kg/ha via selection with water, 30 cm row spacing
Fertilizer application:	Lime 1.5 t/ha, via broadcasting Basal dressing, D'mix 300 kg/ha at emergence Top dressing, Urea 50 + 50 kg/ha at tillering and meiosis stage

2) Summary

a) Early maturing varieties

Table II.1.1.8 shows the result on the grain yields and components for the tested varieties. This cropping season resulted in low yield level. Pooled means were 253.9 gm/m^2 for the late October sowing, and 298.0 gm/m^2 for the late November sowing which exceeded by 17% the 1st sowing, with significance at the 5% level. A significant varietal difference was statistically detected at the 1% level.

In the 1st sowing date, C1158 yielded 358.8 gm/m^2 while other yields ranged around 2 t/ha, with ITA234 scoring the lowest level (183.9 gm/m^2).

ITA234 low yield seemed to be derived from sucked damages by rice bug (Letocorisa varicornis) at the heading stage, which impeded the ripening process. This is supported by the low percentage of filled grains. On the other hand, the 2nd sowing date trial resulted in the highest yield of 454.2 gm/m^2 from Xiang Zhou 5 while both IR8067 and ITA234 yields ranged around 2 t/ha with the lowest ranks. No interaction was statistically detected between variety and sowing date, but some tendency of yield decline was observed for C1158 and ITA222 toward the late November sowing and some increasing yields for the other 5 varieties.

Late October to early January, a mid-late November sowing appears to maximize grain yields. This tendency, of course, varies with the pattern of rainfall and appears to be related to the mitigation of water stress at the initial growth stage. High yielding varieties are ITA series, Xiang Zhou 5, IR8067 and C1158, while a local variety, Angola 2 was a poor yielding variety.

b) Late maturing varieties

Table II.1.1.9 gives the grain yields and components. This cropping season, as similarly recorded in the early varieties, the overall yield level was low with a range of 2 to 4 t/ha. The pooled mean yield value for the 1st and 2nd sowing date were 345.1 gm/m^2 and 246.1 gm/m^2, respectively. That of October sowing date exceeded by 40% that of the late November sowing date, which was opposite to the early varieties' results.

The overall percentage of filled grains was similar to a normal year, but IR8192 showed a sharp decrease in the 2nd sowing date, similarly to the 1990/91 cropping season. This implies that IR8192 seems to be less resistant to rice bugs compared to the other tested varieties. On the other hand, a significant difference over the sowing dates was detected not at the 5% level but at 11.7% level. Moreover, no statistical significance was observed over varietal differences, and over interaction between variety and sowing date. However, consistent with the past 3 year results, early sowing tended to yield more than late sowing at a pooled mean basis. Selecting the optimal sowing date over the 50 days spanning from mid November to early January resulted in mid November sowing as the best date followed by the late October sowing.

From this result, it is inferred that the optimal sowing date for the late rice varieties spans from late October to mid November. High yielding varieties so far observed in these trials are P1369, P2023, IR8192 and BG374-1 while local varieties like Supa and Burma are relatively low yielding.

[Lealui farm in 1991/92]

1) Materials and methods

Field:	Lealui (S-2-2/1,000 m^2)
Experimental design:	Split-plot design with 3 replications
Tested variety:	Angola crystal, Supa, Malawi Faya, Burma
Seed rate:	60 kg/ha via selection with water
Spacing:	30 cm in between rows
Sowing date:	1st sowing/Dec. 2 2nd sowing/Dec. 26
Fertilizer:	Basal dressing, D'mix 200 kg/ha at emergence and initial tillering stage by split application Top dressing, Urea 50 kg/ha + 50 kg/ha at tillering stage before flooding

2) Summary

Table II.1.1.10 shows the result of the grain yields and components for the tested varieties. The yield level this season was similar to a normal year.

The pooled means for the 1st and 2nd sowing dates were 252.9 and 312.1 gm/m^2, respectively, with a 23.4% increase in the 2nd sowing but no significant difference observed. Although an interaction between varieties and sowing dates was not found, a varietal difference was detected at the 1% level.

Angola crystal at both 1st and 2nd sowing dates gave the highest yields, 330.0 and 354.8 gm/m^2 which exceeded 3 t/ha. Meanwhile, the least productive was Malawi faya which yielded around 1 t/ha in both sowing dates.

Outlining the sowing date trials so far over 5 weeks from early December to early January, the grain yield is maximized in mid-late December sowing. Of course, rainfall pattern varies with year, and the optimal sowing date seems to be a short period of around 10 days from mid to late December. That is, late December has a high probability of more rainfall which can help increase the number of panicles/unit area by mitigating water stress at the initial growth of rice plants under harsh environment of the soil and water regime in Lealui.

[Screening trials for drought tolerant varieties in Lealui farm in 1991/92]

1) Objectives

Trials were aimed at examining rice strains tolerant to drought before flooding occurs in a sandy soil with low water retention.

2) Methods and materials

Field:	Lealui, N-1-2/70 m^2
Experimental design:	Single plot/each entry
Tested variety:	31 entries from IRRI with 4 local varieties
Seed rate:	10 gm/entry
Sowing date:	Early Dec. in drilling with 30 cm row space in deep seeding furrow

Fertilizer:	Manure 2 t/ha	
	Basal dressing;	D'mix 200 kg/ha in split application at emergence
	Top dressing;	Urea 50 + 50 kg/ha at tillering & meiosis

3) Summary

In the field with black soil top dressing, drilling the seeds in deep furrows was followed by the application of cattle manure in early December, then carefully covering the plot with soil carefully so as not to destroy the deep furrow, and finally mulching the plot with dry grass. Each variety was sown per row. In order to get an even emergence, a spray irrigation was carried out 3 times so far at a rate of 2 times per week. Having achieved a uniform emergence, the test plot was then put under rainfed condition.

December had 13 days of rain, thus causing only a slight stress on the plants. However, the weather turning dry from January, all entries started to curl leaf blade and to show symptoms of dying-off from leaf tips. Evaluating drought tolerance per entry based on "Standard Evaluation System for Rice by IRRI, 1988", three varieties were found to show no symptom of leaf tip dying-off, with scale zero (See Table II.1.1.11). However, one of them resulted in no grain yield.

From this fact, there is no closed correlation between grain yield and degree of leaf tip dying-off. Among the 35 entries, the highest yielding variety was the local variety, Burma with 284.8 gm/m^2 (See Table II.1.1.11). Meanwhile other local varieties, Angola crystal and Supa exceeded 1 t/ha, but Malawi faya had no filled grains under these harsh drought conditions. Thus, both varieties with other 7 entries exceeding 1 t/ha were found to be drought tolerant.

(2) Field operation trial in 1989/90

1) Objective

Trials were aimed at examining planting patterns of early maturing varieties in a cropping system of early maturing rice and wheat.

2) Materials and methods

Field:	Namushakende (W-1-1)
Experimental design:	RCBD with 2 replications
Variety:	C1158-3
Sowing date:	December 30
Seed rate:	50 kg/ha via selection with water
Plowing & sowing method:	Plowing completely at rice cultivation Drilling on dry bed Row spacing 1) 30 cm 2) 20 - 30 cm 3) 25 cm
Fertilizer application:	Lime at rate of 1.5 t/ha via broadcasting Basal dressing; D'mix 250 kg/ha at sowing time Top dressing; Urea 40 kg/ha at tillering Urea 20 kg/ha and V'mix 200 kg/ha at meiosis Urea 50 kg/ha at booting stage

3) Summary

This trial was carried out at the field following maize, potato and sorghum cultivation, and emergence was uniformly established 5 days after sowing. Generally the appearance of the canopies in the test field varied with ex-crops history.

With respect to seed rate, a variety of high tillering capacity, C1158 was found to get a high grain yield even though seed rate was reduced from 60 kg/ha to 50 kg/ha . Regarding sucked damage by gall midge, a regular spray of insecticide - endsulphan from the seedling stage minimized infestation of this insect. The result of the yield analysis is shown in Table II.1.1.12. The grain yield generally exceeded the high level of 6 t/ha , but no significant difference among the treatments of planting system was found statistically.

(3) Soil improvement trial

[Namushakende farm in 1989/90]

1) Objective:

Trials were aimed at examining methods of peat-muck soil improvement through the cropping system of rice upland crop.

2) Materials and methods:

Farm:	Namushakende (M-1, E-1)
Experimental design:	No replication, 260 m^2/treatment
Variety:	a) Early maturing type, Xiang Zhou 5 b) Late maturing type, ITA222
Cropping system:	Early rice - upland crop (Wheat- shallow peat soil layer/M-1) - upland crop (Maize, deep peat soil layer/E-1)

Soil improvement methods

M-1-1/E-1-1;	Sand dressing with 8 cm thickness Lime applied plot at rate of 1.5 t/ha No lime plot
M-1-2/E-1-2;	No sand dressing with lime application at rate of 1.5 t/ha - Triple superphosphate plot, 250 kg/ha - Fused phosphate plot, 250 kg/ha - Bentonite plot, 5 t/ha - Control plot
Sowing date:	Early maturing variety, November 29 Late maturing variety, December 14
Seed rate:	60 kg/ha via selection with water, drilling on dry bed in 30 cm apart from row

Fertilizer application:

Basal dressing;	Early rice	D'mix 250 kg/ha at emergence
	Late rice	D'mix 300 kg/ha at emergence
Top dressing;	Early rice	Urea 20 kg/ha at tillering Urea 20 kg/ha at meiosis
	Late rice	Urea 30 kg/ha at tillering Urea 70 kg/ha at meiosis

Area tested:

Early rice	2,500 m^2
Late rice	2,500 m^2

3) Summary

a) Early maturing varieties

The emergence of M-1-1 was delayed 2 days compared to M-1-2 which emerged uniformly. With respect to initial growth in late December, the plant height in M-1-2 was about 5 cm higher than that of M-1-1 in average, and furthermore the tillering number/hill was generally 1 to 2 tillers more as well. The result of grain yield and soil pH in each treatment is shown in Table II.1.1.13. Soil pH of the test plot with lime in M-1-1 was slightly higher than that of the control. With respect to date of heading, M-1-2 was 2 to 3 days earlier than that of M-1-1. Testing various soil improvement materials in M-1-2 there was no appreciable differences among treatments in growth conditions. Brown spot came out in all treatments of M-1-2 field during late March to early April but M-1-1 was very slight. The grain yield of a pooled mean in M-1-1 was overall high yield, 504.7 gm/m^2 while M-1-2 was relatively low yield of 434.1 gm/m^2.

It was assumed that M-1-1 (Sand dressed) created favorable conditions for the rhizosphere of the rice plants due to the sand dressing of peat-muck soil. The lime effect on the grain yield was not clear in M-1-1. Bentonite was quite effective on the grain yield increase among various soil conditioners tested in M-1-2, and this was superior to the sand dressing effect. But no appreciable effect of fused phosphate and triple superphosphate was observed on grain yield.

b) Late maturing varieties

Emergence was more or less affected due to the weather conditions at sowing time, with missing plants in E-1-2 (peat-muck soil) compared to E-1-1 (sand dressing). The initial growth of E-1-1 showed a severe growth disuniformity. In E-1-2, a symptom of physiological disorder like orange discoloration starting at the tip of older leaf was observed in all 4 test plots. Heading in E-1-1 was 2 to 3 days earlier than that of E-1-2, and this was the opposite in the early maturing variety.

The growth duration was around 130 days similarly to the early maturing variety. The grain yield (Table II.1.1.14) resulted in 546.5 gms/m^2 in E-1-1 in contrast to 398.9 gm/m^2 in E-1-2 as a pooled mean, and the effect of sand dressing on grain yield was markedly clear in the early maturing variety; however, the effect of bentonite on grain yield in E-1-2 was not clear but that of triple superphosphate was the highest. The lime effect on grain yield was not clear in E-1-1.

[Lealui farm in 1989/90]

1) Objectives

Trials were aimed at investigating methods of sandy soil improvement through the cropping system of rice-upland crops.

2) Materials and methods

Farm:	Lealui (N-1, N-2)
Experimental design:	No replications
Variety:	Angola crystal
Cropping system:	Late maturing rice - upland crop (Maize)

Treatments for soil improvement:

N-1;	Black soil dressing (Approx. 3 cm thickness) 1) Manure at rate of 2 t/ha 2) Rice husk at rate of 1 t/ha 3) Bentonite at rate of 20 t/ha 4) Control
N-2;	No soil dressing 1) Manure at rate of 2 t/ha 2) Rice husk at rate of 1 t/ha 3) Bentonite at rate of 20 t/ha 4) Control
Sowing date:	January 8
Seed rate:	60 kg/ha via selection with water, drilling on dry bed in 30 cm in between rows
Fertilizer application:	Basal dressing; D'mix 200 kg/ha at emergence Top dressing; D'mix 100 kg/ha urea 50 kg/ha at tillering
Area tested:	5,000 m^2

3) Summary

In N-2, tillering in the bentonite plot (BP) was faster than that in the rice husk (RH) and manure plot (MP). But no difference among treatments in N-1 was observed. Generally, leaf color in the black soil dressing (BSD) field showed a dark green but that in no BSD field was light green associated with somewhat stunting growth. From this evidence, it became clear that the effect of BSD on growth played a role in making the fertilizer effect last longer. Apart from the bentonite plot in the no BSD field other treatments showed a nonuniform leaf color. A symptom of physiological disorder came out in the bentonite and rice husk plots.

On the other hand, the bentonite plot in the BSD field got leaf blast. Bentonite raised soil pH but other materials did not. The pooled mean value of grain yield in the BSD field was 357.1 gm/m^2 but in the no BSD field was only 225.1 gm/m^2, resulting in 37% reduction(Table II.1.1.15). The rank of the grain yield among the treatments in the BSD field was control > bentonite > manure > rice husk, while in the no BSD field the order was control > manure > bentonite > rice husk. The lowest yield of the rice husk plot possibly derived from a deficiency of soil moisture as well as fertilizer nutrients.

[Numushakende farm in 1990/91]

1) Objectives

Trials were aimed at examining methods of peat-muck soil improvement and methods of fertilizer application in improved soil via rice-upland cropping system.

2) Materials and methods

Field:	Namushakende E-1 (2,200 m^2)
Experimental design:	Split plot design without replication Only the sand soil dressed plot has 2 reps.
Variety:	Late maturing type of P1369
Plant density:	22.2 stocks/m^2 (row space 30 cm, hill space 15 cm)

Soil improvement method:

a) Comparison of N level to the grain yields in the sand dressed plots; lime is applied;

b) Comparison of the effect of phosphate level, effect of clay soil dressing on the grain yields in the plots without sand dressing; lime is applied to all the plots (NK is standard dosage; clay soil supplied to the 1/3 of the plots formally used as control).

Fertilizer application:

a) Sand soil dressing plots

Basal dressing: D'mix 300 kg/ha at transplanting time

Top dressing:

a. Standard dosage; Urea 30 + 30 kg/ha at tillering and meiosis stage

b. Heavy dosage; Urea 60 + 60 kg/ha at tillering and meiosis stage

b) No sand dressing plot

Basal dressing:

a. NK=30:30 kg/ha (urea and potassium sulfate form in element basis at transplanting time)

b. NPK=30:60:30 (urea, TSP and potassium sulfate form in element basis at transplanting time)

c. NPK=30:120:30 (- ditto -)

Top dressing: Urea 23 + 23 kg/of N/ha at tillering and meiosis

Transplanting date: January 25, 26 (Nursery on Dec. 31)

3) Summary

Zero P-plot showed partially stunted. The result of the grain yields and its growth characteristic are shown in Tables II.1.1.16 (Sand soil dressing plot: SSDP) and II.1.1.17 (No-sand soil dressing plot: NSSDP). Regarding the grain yields in SSDP, the heavy N applied plot resulted in 272.2 gm/m^2, higher than 246.1 gm/m^2 of the standard N dosage; but statistically no significant difference due to spotty soil heterogeneity within the experimental plots. The grain yields level of NSSDP was superior to that of SSDP, and ranged between 340 - 400 gm/m^2 which was opposite to last year results. Namely, the effect of sand soil dressing (done in the cool dry season of 1989) lasted only up to the first rice cropping followed by hot dry season crop. On the other hand, in NSSDP, the effect of phosphate to the grain yields was apparently significant. Especially the number of panicles/m^2 was positively correlated with phosphate dosage among the treatments (Figure II.1.1.1). Further, a residual effect of triple supper phosphate, bentonite and fused phosphate applied in 1989 was not clear when compared with the control. The clay soil dressed this season was also no significant effect to the grain yields.

[Lealui farm in 1990/91]

1) Objectives

Trials were aimed at examining methods of fertilizer application in the improved soil and also examining methods of improving sandy soil.

2) Materials and methods

Field: Lealui (N-1, N-2/5,000 m^2

Experimental design: Split plot design with water, 30 cm row spacing

Tested variety: Angola crystal

Seed rate: 60 kg/ha via selection with water, 30 cm row spacing

Treatment:

a) Black soil dressing plot;

- control
- manuring 2 t/ha
- dried grass 2 t/ha
- green manure 2 t/ha

Fertilizer;

- Basal dressing, D'mix 200 kg/ha 2 times split application
- Top dressing
  a. Standard dosage, Urea 40 kg/ha
  b. High dosage, Urea 70 kg/ha

b) No soil dressing plot;

- manuring 2 t/ha
- dried grass 2 t/ha
- green manure 2 t/ha

Fertilizer;

Basal dressing, D'mix 200 kg/ha

Top dressing, Urea 40 kg/ha

3) Summary

From two to three leaves apparition stage, many individuals with leaf tips turned into brownish locally and outbreak of leaf blast as well. Only one topdressing was done just before inundation. Generally, an appearance of each test field showed a marked difference and the plot of the black soil dressing (BSD) showed a vigorous growth. Meanwhile, the plot of no black soil (NBS) was stunted with partially missing rice plants. The result on the grain yields and growth characteristics are shown in Table II.1.1.18. The grain yields does not always show a closed correlation with the topdressing dosage because of the spotty soil heterogeneity of the experimental plots;

but in the treatment of BSD, the ranking was high > standard dosage, while black soil with organic matter resulted in the order of standard > high dosage, indicating that increasing N dosage resulted in yield decrease. This factor should be further studied.

From this trial result, one of effective method to improve sandy soil was verified by dressing it with black soil but no quick effect on yield increment was observed when applying organic matter to the BSD field.

[Lealui farm in 1991/92]

1) Materials and methods

Field:	Lealui (N-1-1, N-2-2/2,500 m^2)
Experimental design:	Split plot design with no replication
Tested variety:	Angola crystal
Seed rate:	60 kg/ha via selection with water, 30 cm row spacing
Sowing date:	December 31
Treatment:	Total-N = 56 kg/ha

a) Black soil dressed plot; manure 2 t/ha

(i) Basal dressing; D'mix 100 kg/ha at emergence
Top dressing; Urea 56 + 43 kg/ha before flooding

(ii) Basal dressing; D'mix 200 kg/ha at emergence
Top dressing; Urea 43.5 + 35 kg/ha before flooding

b) No black soil dressed plot; manure 2 t/ha

(i) Basal dressing, D'mix 200 kg/ha
Top dressing, Urea 43.5 + 35 kg/ha

(ii) Basal dressing, D'mix 100 kg/ha
Top dressing, Urea 56 + 43 kg/ha

2) Summary

N-2-2 field suffered from frequent poor emergences but the plot in N-2-2 treated with bentonite in 1989/90 had a relatively fair emergence. The rainfall in January was only around 100 mm, but the January evaporation increased up to 145 mm as measured from the pan. This imposed severe water stress to the rice plants from the early stage, thus resulting in uneven growth. However, a clear difference was observed in the topdressing methods (See Table II.1.1.19). That is, the methods stressing basal dressing yielded more if the amount of total-N was constant. In N-1-1, treatment B exceeded treatment A by 43.2% in terms of grain yields, and similarly N-2-2 resulted in 100% increase.

From this fact, it is apparent that the fertilizer application method to accelerate tillering at the initial growth stage by giving a heavy dosage of N was quite effective. So far, various methods to improve sandy soils were tested. Among them, the method of black soil dressing showed a marked effect. But no clear differences were found among tested organic materials except rice husk, which played a negative effect on grain yield. Green manure and cattle manure do not exert a quick effect to increase the grain yields. However, in Lealui fields, with sandy soils where rice plants are exposed to water stress at sowing time, a manuring practice to promote initial growth is recommended by applying organic fertilizer to improve water retentivity and CEC.

(4) Soil bearing capacity related to Oxen-plow

[Measurement in 1990/91]

1) Objective

Trial were aimed at clarifying the relationship between soil hardness and plowing operations by oxen because the farming system trial is in principle based on oxen-plow or man power.

2) Materials and methods

a) 1st year

Field:	Namushakende M-6-2
Device for measurement:	Corn penetrometer by Shibuki shiken kogyo
Method of plowing:	Oxen-plowing
Date of measurement:	October 30
Method of measurement:	Splitting the field into several mesh (mesh size = 8 m x 6 m), three points with three different depth (5, 10, 15 cm) in each mesh were measured by the cone top with 6.45 cm^2 and computed a mean of three measuring figures. Then this was multiplied by an correction index of 0.064 to get qckg/cm^2.

b) 2nd year

Field:	Namushakende M-6-1 peat-muck soil M-3-2 sandy soil E-3-2 peat-muck soil
Device for measurement:	Same as the 1st year
Method of plowing:	Same as the 1st year
Date of measurement:	November 1
Method of measurement:	Same as the 1st year
Record taken:	M-6-1/soil bearing capacity (5, 10, 15 cm depth), M-3-2 & E-3-2/change of soil bearing capacity (3 different depths) over time, up to flooding every week, Underground water level & soil moisture content at every depth

3) Summary

a) Measurement in 90/91

In late October of early rainy season, oxen plowing operation by 4 middle size oxen was tested in M-6 field measuring soil bearing capacity (SBC) by a cone penetrometer. This field 2,500 m^2 has a thickness gradient of peat-muck soil layer from north-west of 15-20 cm to south-east of more than 60 cm. This gradient showed the tendency of SBC decreasing toward the south-east.

After plowing the field, getting a tooth harrow by large size of 4 head oxen pulling in the field, M-6-1 with shallow peat-muck soil layer (15-50 cm) had enough SBC to support heavy oxen's operations. However, overall M-6-2 field beyond 50 cm depth failed to support the heavy oxen. Table II.1.1.19 shows the result of analyses on SBC. The measured figure is the values analyzed from measuring each mesh (by splitting into the size of 8 m East-West side and 6 m North-South side) in the east half field, where more than 50 cm peat-muck soil layer extended. The point the oxen stuck was closed to "B" point, and the cone index (CI) of each 5, 10, 15 cm depth was 1.81, 0.68, 0.46 kg/cm^2 respectively. From this result, the points of B, where the oxen passed without getting stuck had at least 2.45 kg/cm^2 of CI, was regarded as a threshold value to introduce oxen plow.

b) Measurement in 1991/92

i) The relation between oxen plow and soil bearing capacity

The oxen plowing operation was tested in M-6-1, where a relatively thin layer of peat-muck soil (15 - 50 cm depth) lies, with measuring SBC. In this field, SBC gradually decreased from north-west to south-east like concentric circles; the south-east corner was the thickest while the north-west corner was the thinnest, and the sandy soil was underlain beneath. Thus, the plowing operation by oxen also reflected this soil matrix; that is, toward the south-east of the field, a burrying-depth of the oxen hooves increased with dropping efficiency. Table II.1.1.20 gives the result of a mean value of the SBC measured over 3 points by depth (5, 10, 15 cm) in each mesh, by splitting M-6-1 into 4 divisions from both north-south and east-west sides. The shaded point (4A) of M-6-1 was the site where the oxen hooves were likely to get stuck and affect the work efficiency. The stuck point of hooves in Table II.1.1.21 obtained 0.96, 0.38 and 0.34 kg/cm^2 from the soil surface, while A2 point was plowed without severe problem.

Comparing A2 with A4 as to the cone bearing capacity (CBC), there was no difference at 5 cm depth but at 10, 15 cm depth, A2 exceeded A4 in CBC and indicated around 0.8 kg/cm^2 where middle size oxen could plow without major problems. From these results, it is inferred that at least 0.8 kg/cm^2 of CBC is necessary up to 15 cm depth for middle size oxen. This estimated value, however, is smaller than the value predicted last year at 5 cm depth. Thus, CBC of 10 and 15 cm depth appears to be more significant than that of 5 cm depth for oxen plowing operation.

ii) Fluctuation of bearing capacity over time

The CBC and moisture ratio of the soil were measured over 6 weeks from late October to mid December till both measuring points flooded. M-3-2 was a sandy soil, and E-3-2 was a thick layer of peat-muck soil. The measurement was done at depths 5, 10 and 15 cm at each site. Figures II.1.1.2 and II.1.1.3 illustrate the change of CBC, moisture ratio and underground water level over 6 weeks. The CBC by depth over different soil type showed a reciprocal curve; that is, in the sandy soil the surface layer has the lowest CBC which increased downwards. Meanwhile, the peat-muck soil had a CBC decreasing from surface downwards. It can be inferred that the CBC increased because of the porosity between soil particles being filled-up when moving downward in the sandy soil. On the contrary, in the peat-muck soil, the CBC increased due to the desiccation and shrinkage of the surface soil, while in lower layers, the soils became saturated and swelling contributed to decrease CBC. The moisture ratio (MR), however, resulted in the opposite of the CBC curve. That is, in the peat-muck soil MR increased towards lower layers but in the sandy soil it decreased. The fluctuation over time indicated that the CBC at 10 to 15 cm depth in the sandy soil dropped at 3 to 4 kg/cm^2 following the heavy rain on November 5th (43 mm), and then remained constant without big variations. In the peat-muck soil, only the surface CBC (5 cm depth) gradually decreased over 6 weeks up to December 18 when the field flooded. And its lower layers (10, 15 cm depth) remained around 0.5 kg/cm^2 without major changes except in November 7, as in the sandy soil. Consequently, the CBC of 5 cm depth decreased gradually up to 0.5 kg/cm^2 and became no different with depth at flooding time. In the sandy soil, the CBC over 3 different depths fluctuated in parallel even after flooding and a big gap was observed in terms of the CBC values compared with the peat-muck soil. The measuring point at E-3-2 has a thickness of peat-muck soil layer of more than 2 m, and at the end of the dry season showed a CBC of 2.67, 0.62, and 0.45 kg/cm^2 from top to bottom, sharply dropping one-fourth to one-sixth of its original value when the depth varied from 5 cm to 10 cm and 15 cm.

As discussed in Chapter i) the relation between oxen plow and soil bearing capacity, a CBC of 0.8 kg/cm^2 at 15 cm depth was estimated necessary for introducing an oxen plow, and this made it clear that the aspect of the peat-mucky soil in which the CBC dropped sharply from top to bottom made oxen plow difficult. Thus, there are two ways to improve CBC of the peat-muck soil: 1) sand dressing, and 2) drop underground water level by improving the drainage system; but the former is costly when applied to a large area and the latter is unapplicable during the rainy season.

From this discussion, it is concluded that oxen plow is troublesome throughout the year in the plain edge where thick peat-muck soil layer lies associated with drainage difficulties, but can be introduced in the sandy soil even under flood conditions.

Table II.1.1.1 Grain Yield and Components

No	Vaviety	Grain Yield (g/m2)			No. of Panicles /m2			No. of Spiklets /m2			Filled Grains (%)			1000 Grain W+G (g)			Culm Length (cm)			G/S Ratio		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1	IR 54	317.6	295.4	198.7	208.7	209.8	195.4	14971	19527	10393	79.8	61.4	74.1	26.6	24.6	25.8	41.1	37.3	33.8	0.72	0.69	0.81
2	IR24623-43-2	339.7	122.6	232.4	257.5	174.3	156.5	18020	8418	11301	74.2	60.2	73.0	25.4	24.2	28.2	45.8	28.3	34.7	0.73	0.56	1.10
3	IR8067-41-1E-P1	432.7	219.5	413.8	239.8	172.1	215.3	25752	15810	20389	70.3	63.4	81.5	23.9	21.9	24.9	45.5	40.9	47.3	1.03	0.89	1.20
4	C1158-3	431.4	413.4	486.1	417.4	277.5	305.3	33655	23450	29642	58.1	62.1	69.2	22.1	23.4	23.7	33.5	35.6	34.4	0.95	1.10	1.40
5	P1369-4-16M-2M-4	369.0	326.1	458.6	314.1	197.6	207.6	27094	14386	19892	57.8	91.4	87.7	23.5	24.8	26.1	33.3	36.5	38.6	0.70	0.81	1.00
6	P2023-F4-53-1B1B	530.4	198.5	262.7	225.3	126.5	147.6	25479	11206	10769	77.1	70.0	92.4	27.0	25.3	26.3	45.8	36.8	38.6	0.78	1.20	1.20
7	IR8192-166-2-2-3	425.8	141.5	297.8	177.6	133.2	166.5	34903	8192	16214	50.5	69.8	72.3	24.4	24.8	25.4	49.0	39.1	50.2	0.79	0.27	0.81
8	BG 374-1	346.0	261.9	232.1	142.1	139.9	119.9	17093	13699	11660	85.4	81.7	91.3	23.7	23.4	21.8	46.8	40.8	35.1	0.85	0.89	0.87
9	KALEMBWE	542.5	286.7	365.9	145.5	169.8	143.2	23732	16938	16855	75.2	73.6	72.6	30.4	23.0	29.9	71.8	65.7	77.4	1.10	1.20	1.00
10	ANGOLA 2	467.5	258.7	309.6	164.3	115.4	111.0	22585	12737	13727	76.1	82.9	84.8	27.2	24.5	26.6	75.0	63.1	79.0	1.10	0.70	3.10
11	ITA 225	429.8	216.6	467.1	187.6	141.0	174.3	19557	12344	20982	90.2	63.3	79.8	27.4	27.7	27.9	46.6	40.9	41.9	0.78	0.87	1.20
12	ITA 222	414.0	263.6	233.3	198.7	134.3	93.2	20939	14181	10884	71.9	69.1	76.0	27.5	26.9	28.2	43.7	37.9	35.0	1.27	1.13	1.30
13	ITA 306	349.3	292.2	275.9	165.4	129.9	132.1	16211	13746	12266	76.2	79.6	83.0	28.2	26.7	27.1	43.6	41.2	39.2	1.04	1.10	1.30
14	CHINA 998	244.6	237.7	214.3	174.3	126.5	138.8	11671	11872	9104	79.7	64.8	80.6	26.3	30.9	29.2	52.7	60.3	55.3	0.74	0.68	0.70
15	MALAWI FAYA	155.8	109.6	347.3	195.4	114.3	133.2	19875	13895	30628	27.7	30.3	37.2	28.3	26.0	30.5	78.2	64.4	52.5	0.20	0.26	0.89
16	RP 1082-24-1-1-1	295.3	247.1	336.8	181.0	173.2	196.5	17974	13091	21335	62.7	71.5	59.8	26.2	26.4	26.4	35.6	35.4	33.7	0.92	0.75	1.10
17	BURMA	138.5	156.3	261.9	147.6	119.9	144.3	15548	7960	16639	29.4	59.5	52.3	30.3	33.0	30.1	72.6	70.0	82.5	0.34	0.41	0.50
18	ANGOLA CRYSTAL	349.3	624.3	360.1	154.3	190.9	118.8	13618	24527	14195	82.2	80.8	81.3	31.2	31.5	31.2	79.9	94.1	76.1	0.87	0.73	1.20
19	XIANG ZHOU 5	355.3	519.3	314.7	166.5	183.2	143.2	16555	21409	13707	69.9	77.0	82.3	30.7	31.5	27.9	41.0	46.5	45.8	1.00	0.92	1.30
20	ITA 234	407.7	331.4	-	226.4	170.9	-	19912	15147	-	75.8	75.7	-	27.0	28.9	-	41.1	42.7	-	1.14	0.96	-

* 1: Nov. 15 2: Nov.30 3: Dec.15

(Namushakende Farm : 1988/89)

Table II.1.1.2 Yield and Yield Components of Early Maturing Varieties

(Namushakende Farm 1989/90)

Cultivar	Paddy Yield (gm/m2 at 14%)			No. of Panicles/m2			No. of Spikelets/m2			Percentage of filled-spikelets(%)			1000 Grain Weight (g)			Culm Length (cm)			Grain/Straw Ratio		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
IR8067	357	382	403	395	398	460	17,545	18,805	23,164	82.5	89.1	77.2	24.5	22.9	22.3	44.5	46.1	45.4	1.06	1.23	1.09
C 1158-3	365	357	426	462	485	605	22,999	18,807	26,613	72.6	83.9	73.4	22.5	22.7	22.1	36.9	34.1	34.9	1.07	1.01	1.04
Kalembwe	209	218	284	244	277	328	13,693	10,197	12,786	65.6	73.6	74.9	28.6	29.2	29.6	68.1	60.1	71.2	0.59	0.58	0.61
Angola 2	304	271	338	299	300	286	13,288	11,949	13,747	77.3	81.3	84.0	29.5	27.1	28.1	73.2	62.3	71.5	0.74	0.66	0.76
ITA 225	394	425	472	378	397	464	19,114	19,120	24,781	76.4	82.5	75.6	27.7	26.9	29.3	43.3	43.9	41.1	1.01	1.11	1.11
Xiang Zhou 5	260	401	376	252	323	347	11,010	15,980	15,425	77.7	87.8	84.0	30.6	29.0	28.9	44.1	47.5	45.0	1.10	1.12	1.06
ITA 234	401	381	500	340	314	472	17,527	17,775	26,838	77.4	76.9	72.3	29.5	27.5	25.9	40.2	38.3	41.5	0.97	1.15	1.03

Table II.1.1.3 Yield and Yield Components of Late Maturing Varieties

(Namushakende Farm 1989/90)

Cultivar	Paddy Yield (g/m2 at 14%)			No. of Panicles/m2			No. of Spikelets/m2			Percentage of filled-spikelets(%)			1000 Grain Weight (g)			Total Weigth (gm/m2)			Grain/Straw Ratio		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
P 1369	394	354	321	480	499	590	19,822	24,856	22,415	85.2	69.1	65.5	22.9	20.9	21.6	1,226	800	877	0.75	0.78	0.73
P 2023	309	311	284	492	503	456	20,178	24,539	19,869	62.0	57.4	57.8	23.7	22.9	22.3	925	903	601	0.78	0.82	0.72
IR 8192	398	286	290	507	450	412	24,492	16,885	21,183	66.4	72.0	61.6	23.7	22.9	21.2	1,098	1,003	753	0.66	0.85	0.53
ITA 222	469	253	302	399	417	489	22,534	16,669	26,913	76.6	58.1	49.2	27.3	25.8	24.1	1,216	786	730	0.97	0.87	0.71
Burma	340	212	188	294	357	341	23,670	17,014	12,535	52.2	46.7	54.2	26.4	25.6	28.0	1,285	951	647	0.39	0.35	0.47
Supa	178	95	74	271	268	282	9,998	6,689	5,629	54.9	46.1	42.2	31.2	29.4	30.2	1,203	911	971	0.28	0.18	0.17

Table II.1.1.4 The Result of Yields and Yield Components for Deep Water Rice

(Lealui Farm : 1989/90)

	Paddy Yield (g/m2 at 14%)		No. of Panicles/m2		No. of Spikelets/m2		Percentage of filled-spikelets(%)		1000 Grain Weight (g)		Culm Length (g/m2)		Grain/Straw Ratio	
Cultivar	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Malawi Faya	256	238	265	362	16,736	14,774	68.5	66.1	22.5	23.4	66.4	67.2	0.49	0.57
Buruma	226	217	288	261	11,968	11,489	69.4	67.6	27.2	28.6	64.5	64.2	0.85	0.66
Supa	242	247	255	282	10,577	10,882	71.0	70.2	32.1	32.3	63.0	65.3	0.70	0.64
Angola Crystal	227	300	260	212	10,173	12,768	80.5	78.5	27.5	29.1	64.7	74.9	0.88	0.82

Table II.1.1.5 The Result of Grain Yields and Yield Components for Early Maturing Cultivars

(Namshakende Farm : 1990/91)

	Grain Yield (g/m2 at 14%)		No. of Panicles / m2		No. of Spikelcts / m2		Percentage of filled-spikelets(%)		1000 Grain Weight (g)		Culm Length (cm)		Grain/Straw Ratio	
Cultivar	1	2	1	2	1	2	1	2	1	2	1	2	1	2
IR 8067	406.1	627.7	438.6	535.0	20151.8	37717.3	85.8	70.0	22.9	23.9	51.2±1.3	51.8±5.9	0.97	1.03
C 1158	441.3	404.7	589.3	477.3	22990.5	23015.1	79.3	76.9	22.8	22.9	42.6±6.0	36.8±5.0	0.97	1.10
Angola 2	331.8	402.9	336.0	259.5	14898.1	18699.8	79.8	75.8	27.8	28.1	71.8±6.8	71.5±12.0	0.63	0.81
ITA 225	379.2	780.7	393.4	356.4	18665.2	40806.9	76.3	72.6	25.9	26.9	47.2±5.2	41.8±3.7	0.84	1.13
Xiang Zhou 5	356.4	457.6	381.3	294.2	16228.8	20895.1	76.5	79.0	28.5	28.2	47.1±5.0	46.3±5.3	0.78	1.22
ITA 234	397.0	723.5	380.0	458.6	21546.6	48840.6	68.2	54.9	25.4	27.1	46.1±5.0	38.4±3.0	0.91	0.62
ITA 222	586.5	600.3	402.7	419.4	26091.1	40203.9	79.1	58.0	28.3	27.5	47.5±2.9	40.6±2.7	1.11	1.06

Note : Figure is the mean of 3 replications

Table II.1.1.6 The Result of Grain Yields and Yield Components for Late Maturing Cultivars

(Namshakende Farm : 1990/91)

	Grain Yield (g/m2 at 14%)		No. of Panicles / m2		No. of Spikelcts / m2		Percentage of filled-spikelets(%)		1000 Grain Weight (g)		Culm Length (cm)		Grain/Straw Ratio	
Cultivar	1	2	1	2	1	2	1	2	1	2	1	2	1	2
P 1369	414.8	348.0	459.3	507.5	25138.6	27631.5	78.9	63.5	21.1	19.9	42.1±4.2	32.5±2.8	0.81	0.66
P 2023	432.4	309.3	373.3	519.0	25383.5	28735.3	72.5	47.9	23.5	21.2	45.3±3.1	30.5±3.4	0.84	0.65
IR 8192	362.0	230.8	373.2	400.9	24290.6	29823.7	69.3	34.1	21.6	21.7	52.7±8.2	38.3±5.5	0.64	0.28
Burma	237.4	244.3	281.7	312.8	17956.3	15738.3	50.9	58.5	26.4	26.6	80.4±10.5	69.2±5.0	0.29	0.54
BG 374-1	326.0	388.5	319.9	333.3	23514.5	30066.8	74.1	64.2	18.8	19.7	49.7±4.2	39.2±3.4	0.72	0.76

Note : Figure is the mean of 3 replications

Table II.1.1.7 The Result of the Grain Yield and Yield Components for Deep Water Rice in Variety x Sowing Date Trial

(Lealui Farm : 1990/91)

	Grain Yield (g/m2 at 14%)		No. of Panicles/m2		No. of Spikelets/m2		Percentage of filled-spikelets(%)		1000 Grain Weight (g)		Culm Length (cm)		Grain/Straw Ratio	
Cultivar	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Malawi Faya	310.5	212.7	241.8	212.7	16173.3	15013.8	68.4	52.7	28.2	27.0	105.1±7.5	110.0±19.3	0.37	0.29
Burma	255.5	296.2	280.8	296.0	11691.2	12677.9	74.7	78.3	29.4	30.1	97.1±7.2	110.4±16.9	0.69	0.57
Supa	197.7	115.2	229.3	196.0	8545.0	4672.5	79.9	80.3	28.7	29.7	90.3±15.8	93.8±16.4	0.35	0.43
Angola 7	334.9	211.3	285.2	254.7	11960.9	7922.5	88.9	85.3	31.6	31.4	93.4±5.9	94.3±10.4	1.14	0.77

Table II.1.1.8 Yield and Yield Components for Early Maturing Varieties

(Namushakende Farm 1991/92)

	Grain Yield 3) (g/m2)		No. of Panicles / m2		No. of Spikelets / m2		Percentage of Filled Grain		1000 Grain Weight (g)		Main Culm Length (cm)		Grain/Straw Ratio	
Cultivar	1*	2**	1	2	1	2	1	2	1	2	1	2	1	2
IR 8067	207.0	222.5	396.4	339.4	13852.8	15529.8	69.1	67.2	21.7	21.1	43.3±3.8	48.4±5.2	0.68	0.95
C 1158	358.8	312.7	530.6	488.8	22564.4	25224.2	68.9	59.8	22.4	21.0	33.8±3.6	39.6±8.7	0.82	0.92
Angola 2	204.7	304.7	294.2	239.1	12942.8	16027.6	58.9	71.7	26.9	26.6	60.6±6.5	66.6±8.7	0.56	0.88
ITA 225	279.3	305.6	328.0	279.9	16610.9	19905.4	66.9	62.7	25.3	24.9	45.3±5.0	50.5±4.6	0.81	0.90
Xiang Zhou 5	272.5	454.2	264.0	242.6	16361.0	13671.2	60.3	81.3	27.8	27.2	44.9±5.5	52.3±4.5	0.73	1.50
ITA 234	183.9	224.3	290.6	276.4	13216.6	20393.1	55.5	45.6	25.3	24.3	42.3±4.2	43.1±3.9	0.71	0.66
ITA 222	271.1	262.1	293.3	315.5	16769.3	21023.4	62.7	51.6	25.3	24.2	41.0±5.0	44.7±4.7	0.78	0.80

Note *1 : Sown on October 25
**2 : Sown on November 28
3 : Sowing date is significant difference at 5% level. (LSD 0.05=35.7 gm/m2)
Varietal difference is significant difference at 1% level. (LSD 0.01=154.1 gm/m2)

Table II.1.1.9 Yield and Yield Components of Late Maturing Varieties

(Namushakende Farm : 1991/92)

Variety	Grain Yield (gm/m2 at 14%)		No. of Panicles m2		No. of Spikelets m2		Percentage of Filled-Grain (%)		1000 Grain Weight (gm)		Main Culm Length (cm)		Grain/Straw Ratio	
	1*	2**	1	2	1	2	1	2	1	2	1	2	1	2
P 1369	313.9	263.3	326.2	410.6	19250.6	21121.6	77.1	56.7	21.2	21.7	45.1±3.9	43.6±3.9	0.78	0.49
P 2023	413.8	211.6	328.0	407.1	28867.3	20422.3	62.1	49.7	23.7	22.1	49.5±4.7	45.9±5.0	0.79	0.56
IR 8192	325.4	215.0	336.9	303.9	20196.5	26491.4	70.6	39.4	22.8	21.1	53.9±5.7	52.5±4.5	0.81	0.36
Burma	335.7	245.2	301.3	267.5	21029.4	16662.7	55.7	53.9	29.1	27.4	91.3±9.5	81.8±7.9	0.33	0.31
BG 374-1	336.9	295.9	327.1	307.5	22910.9	21716.2	69.8	53.5	21.7	21.6	49.8±6.4	49.6±5.9	0.92	0.58

Note) *1 : Sown on October 25
**2 : Sown on November 28

Table II.1.1.10 The Result of Yield and Yield Components of the Semi-deep Rice Varieties

(Lealui Farm 1991/92)

Variety	Grain Yield (gm/m2)*		No. of Panicles m2		No. of Spikelcts m2		Percentage of Filled-Grain (%)		1000 Grain Weight (gm)		Main Culm Length (cm)		Grain/Straw Ratio	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Angola Crystal	330.0	354.8	365.5	442.0	18871.5	20535.8	67.1	71.1	26.0	24.0	64.8±6.7	64.6±11.0	0.87	0.77
Supa	284.1	261.5	362.6	408.9	16100.2	25639.0	71.0	45.8	25.1	23.7	71.2±3.8	66.2±4.6	0.75	0.41
Malawi Faya	164.1	79.0	454.2	-	29334.5	-	31.7	-	19.8	-	58.5±6.3	-	0.36	-
Burma	233.4	324.9	428.4	375.0	16137.5	22270.9	61.2	60.4	23.4	24.3	56.8±6.3	66.6±9.1	0.90	0.71

Note) * : Varietal difference is significant difference at 5% level (LSD 0.05=72.1 gm/m2)

Table II.1.1.11 The Result of Drought Tolerance Screening Trial

(Lealui Farm : 1991/92)

Variety	Grain Yield (gm/m2)	No. of Panicles m2	Grain / Straw Ratio	Culm Length (cm)	Main Culm Length (cm)
1 Dular	87.2	298.3	0.37	47.6±3.4	1
2 Djoweh	-	-	-	-	3
3 N22	113.8	249.9	0.47	38.9±2.9	1
4 Rikuto Norin 21	42.9	120.0	0.32	46.1±4.4	1
5 Cartuna	61.7	163.3	0.26	37.1±4.5	1
6 Moroberekan	45.1	63.3	0.15	45.7±7.4	1
7 Padi Tatakin	75.7	85.0	0.43	38.5±2.7	3
8 Seratus Malan	68.6	94.9	0.28	54.9±4.8	1
9 13A	-	-	-	-	1
10 20A	32.6	45.0	0.16	45.4±6.5	1
11 24A	41.4	64.9	0.18	52.9±6.5	3
12 270	31.0	54.9	0.08	41.9±9.5	3
13 Buluhan Yakei 289	-	-	-	-	1
14 Ex Dan	12.6	74.9	0.04	47.2±5.4	1
15 Ex Faramana	105.6	173.3	0.48	45.1±4.7	3
16 Ex Gotor-Pujehun	0.4	10.0	0.002	28.8±4.0	3
17 Pa Therei	42.9	166.5	0.27	34.6±4.8	3
18 IR12979-24-1	157.6	150.0	0.65	34.6±4.8	3
19 IR30716-B-1-B-1-2	171.9	210.0	0.79	35.4±3.8	3
20 IR27095-20-18	32.4	131.5	0.20	33.1±4.8	1
21 IR10120-7-2-1-4	132.2	194.8	0.57	37.4±4.8	1
22 IAC 25	113.9	78.3	0.86	43.0±5.4	1
23 OS 4	16.7	73.3	0.17	31.9±3.7	1
24 3000	-	-	-	-	1
25 IR9782-111-2-1-2	-	-	-	-	0
26 IRAT 104	48.6	123.2	0.24	43.3±4.3	1
27 IRAT 116	28.4	73.3	0.11	42.6±7.4	1
28 IRAT 134	62.4	106.7	0.75	31.2±2.7	0
29 IRAT 140	77.9	103.3	0.41	40.0±4.3	1
30 IRAT 142	99.0	106.7	0.74	42.7±3.3	0
31 IRAT 186	128.7	205.0	0.32	50.8±5.5	1
32 Angola Crystal	125.8	178.2	0.50	49.0±7.9	3
33 Supa	166.8	216.5	0.37	63.7±3.0	3
34 Malawi Faya	4.7	63.3	0.008	33.9±5.8	1
35 Burma	284.8	278.3	0.90	43.6±6.2	3

Note : Excluded the variety with no grain yield. The measurement was done on January 29 (Tillering stage).

Table II.1.1.12 The Result of Grain Yield Analysis for Planting Pattern Trial of Early Maturing Varieties

Tested Variety : C 1158
(Namushakende : 1989/90)

Planting Pattern	Paddy Yield g/m2	No. of Panicles m2	Grain / Straw Ratio	Culm Length (cm)
RS 1	650.0	619.5	1.25	39.8
RS 2	634.1	630.5	1.25	42.7
RS 3	605.3	618.5	1.25	37.8

Note : RS 1 : Row Space 30cm
RS 2 : Row Space 20~30cm
RS 3 : Row Space 25cm

Table II.1.1.13 The Result of Grain Yield Analysis for Soil Improvement Trial

(Namushakende Farm : 1989/90 Tested Variety : Xiang Zhou 5)

Soil Treatment		Paddy Yield (g/m²)	No of Panicles /m²	Grain / Straw Ratio	Culm Length (cm)	Soil pH
Peat-muck Soil	Triple Super-phosphate	396.6	256.7	1.00	44.6±3.6	3.8
	Fused phosphate	393.2	216.7	1.20	46.4±3.7	4.0
	Bentonite	546.0	276.7	1.20	52.2±6.9	4.1
	Control	401.0	277.8	1.10	41.1±2.6	4.5
	Mean	434.1	257.0		46.1±4.6	4.1
Sand Dressing plot	-Ca	540.4	308.9	0.99	41.9±3.3	4.2
	+Ca	490.4	262.8	1.00	43.5±2.9	4.4
	+Ca	508.6	285.0	0.93	49.9±2.7	5.6
	-Ca	479.3	301.7	0.80	46.9±2.8	4.0
	Mean	504.7	289.6		45.6±3.6	4.6

Table II.1.1.14 The Result of Grain Yield Analysis for Soil Improvement Trial

(Namushakende Farm : 1989/90 Tesied Variety : ITA 222)

Soil Treatment		Paddy Yield (g/m²)	No of Panicles /m²	Grain / Straw Ratio	Culm Length (cm)
Peat-muck Soil	Triple Super-phosphate	484.1	371.1	1.13	41.5±2.6
	Fused phosphate	367.8	345.0	0.85	44.8±2.6
	Bentonite	393.2	323.9	1.19	39.5±1.7
	Control	350.4	313.9	0.91	39.3±2.4
	Mean	398.9	338.5	1.02	41.3±2.6
Sand Dressing plot	-Ca	595.3	487.8	0.93	46.5±2.3
	+Ca	602.9	341.1	1.43	45.5±2.2
	+Ca	510.9	409.4	0.87	41.4±1.9
	-Ca	477.0	398.9	1.10	37.1±4.9
	Mean	546.5	409.3	1.08	42.6±2.6

Table II.1.1.15 The Result of Grain Yield Analysis for Soil Improvement Trial

Tested Variety : Angola Crystal

(Lealui Farm : 1989/90)

Treatment	Paddy Yield (gm/m2)	No of Panicles m2	Grain / Straw Ratio	Culm Length (cm)
Black Soil (Soil Dressing)	379.1	318.3	0.72	77.3±5.4
Black Soil / Bentonite	372.1	364.2	0.70	81.1±10.7
Black Soil / Rice husk	312.4	312.5	0.66	70.4±11.3
Black Soil / Manure	367.2	300.9	0.70	79.4±6.0
Sandy Soil	264.8	288.3	0.53	72.1±5.5
Sandy Soil / Bentonite	226.4	262.5	0.57	66.8±10.3
Sandy Soil / Rice husk	179.3	246.7	0.51	65.8±7.6
Sandy Soil / Manure	230	274.2	0.53	77.8±9.9

Table II.1.1.16 The Result of N-effect to the Grain Yields in Soil Improvement Trial

(field of sand soil dressing)
(Namushakende Farm : 1990/91)

N-treatment for Top dressing	Grain Yield (gm/m2 at 14%)	Culm Length (cm)	Grain/straw Ratio	No of Panicles (Per m2)
30+30 kg/ha	246.1	35.5±2.4	0.76	206.7
60+60 kg/ha	272.0	36.0±4.1	0.76	221.3

Cultivar : P 1369 Note : Figure is the mean of 2 Replications.

Table II.1.1.17 The Result of P-effect to the Grain Yields in Soil Improvement Trial

(Field of no-sand soil dressing)
(Namushakende Farm : 1990/91)
Tested cultivar : P1369

Privious treatment	P-treatment*	Grain Yield (gm/m2 at 14%)	Culm Length (cm)	Straw/Grain Ratio	No of Panicles (/m2)
Triple Super Phosphate	NK	317.6	44.8±3.9	1.00	117.0
	NPK(S)	340.1	41.7±4.1	0.79	161.5
	NPK(H)	433.2	43.0±2.6	0.90	198.5
Fused Phosphate	NK	341.9	39.9±2.1	0.91	148.1
	NPK(S)	417.2	42.8±1.9	0.78	231.1
	NPK(H)	463.3	42.3±3.5	0.75	256.3
Bentonite	NK	368.6	40.3±1.7	0.89	151.0
	NPK(S)	360.6	39.7±1.7	1.26	120.0
	NPK(H)	388.8	39.4±2.1	0.87	162.9
Clay Soil Dressing	NK	248.3	38.2±8.7	0.56	170.4
	NPK(S)	383.5	38.6±1.3	0.66	232.6
	NPK(H)	343.8	39.1±7.4	0.68	253.3
Control	NK	333.6	39.1±2.1	0.87	158.5
	NPK(S)	402.5	40.6±2.9	0.85	186.6
	NPK(H)	380.1	38.8±6.6	0.74	192.6

* P treatment was done by applying a form of triple super phosphate.
(S) refers to standard dosage, (H) refers to high dosage.

Table II.1.1.18 The Result of the Grain Yield & Growth Characteristics in Soil Improvement Trial

(Lealui Farm : 1990/91)

Soil Treatment	N-Topdressing Level (urea)	Grain Yield (gm/m2 at 14%)	Culm Length (cm)	Straw/Grain Ratio	No of Panicles (/m2)
Black Soil (BS) dressing	40 kg/ha	374.5	104.0±7.2	0.52	256.7
	70	399.1	104.2±9.2	0.58	253.2
BS + Dried Grass 2 t/ha	40	282.7	81.9±5.4	0.94	190.0
	70	257.5	89.7±5.7	0.77	145.0
BS + Green Manure 2 t/ha	40	296.2	87.9±9.2	0.73	94.0
	70	213.1	80.0±4.0	0.91	130.0
BS + Manure 2 t/ha	40	312.6	89.8±6.4	0.69	186.6
	70	252.6	84.1±6.2	0.89	181.7
Dried Grass 2 t/ha	40	301.6	99.9±8.2	0.83	166.6
Green Manure 2 t/ha	40	165.2	81.1±5.9	0.72	139.2
Manure 2 t/ha	40	212.2	80.0±5.1	1.02	110.0

Tested Cultivar : Angola Crystal

Table II.1.1.19 The Result of Soil Improvement Trial

(Lealui Farm : 1991/92)

Treatment	Topdressing Method	Grain Yield (gm/m2)	No. of Panicles/ m2	Grain/Straw Ratio	Culm Length (cm)
N-1-1	A	279.4	299.0	0.62	70.4±8.1
	B	400.2	341.7	0.85	74.0±6.0
N-2-2	A	141.4	188.3	0.53	53.8±4.4
	B	282.9	241.6	0.79	62.5±4.4

II.1.2 Upland Crops in the Cool Dry Season

(1) Wheat

1) Variety and sowing date trials for wheat (1991)

a) Objectives

To study the wheat varieties and their crop calendar for suitability in the cool dry season after early rice.

b) Materials and methods

Field:	Namushakende W-2-(2)
Varieties:	Loerie I, Loerie II, Coucal, J 130, Jupateco, Whydah, Canary, Emu.
Sowing date:	19th April (early), 10th May (late)
Liming:	1 t/ha, broadcasting
Fertilizer:	Basal; D'mix 300 kg/ha, $CuSO_4$ 30 kg/ha Top dressing; Urea 85 kg/ha (3 weeks after emergence)
Sowing method:	Seed rate 80 kg/ha, drilling with 25 cm level row width
Plot size:	Split plot with four replications, one plot 7.5 m^2

c) Results

i) Plot sown on 19th April

Emergence was almost uniform in all varieties except in some damaged by rats. Stem elongation began during late May and early June, earing was about 20th June and maturation between 10th and 20th August. This season, on 9th June minimum temperature dropped to 2°C resulting in damage of young panicles by cold.

Grain yields of the plot sown on 19th April are shown in Table II.1.2.1. As described before this plot got severe cold damage in young panicles just after stem elongation resulting in very low yields in all varieties with no possibilities of comparison.

ii) Plot sown on 10th May

As rat control was practiced during sowing operation emergence was uniform in all varieties. Growth after emergence was also good reaching stem elongation on late June and earing on middle and late July. There were not so severe damages by rats during maturation which was reached in good condition by all varieties at about 10th September.

Grain yields of the plot sown on 10th May are shown in Table II.1.2.2. All varieties showed good results and fields exceeded 2 t/ha in half of the varieties. Especially, Jupateco and Loerie II showed higher yields with 2.50 t/ha and 2.34 t/ha respectively. From the statistical analysis in Table II.1.2.2 there are no significant differences between Jupateco and the three varieties Loerie II, J 130 and Coucal. But Jupateco shows significantly (1 ~ 5% level) higher yield than varieties other than the three described above, and Loerie II shows higher yield than Canary, Loerie I, and Whydah at the 5% significant level. There are no significant differences between J 130 and the four lowest yielding varieties

d) Discussion including the results of the previous years

Among the outstanding varieties of the year, Loerie II and Coucal showed also good results last year. The yields of the two higher yielding varieties (Jupateco and Loerie II) of this year are near the yield (2.68 t/ha)of the Karabo Agricultural Project in 1988 where the soil is mucky with sand. It can be said that Jupateco, Loerie II, J 130, and Coucal are suitable varieties for Namushakende mucky soil.

Wheat varietal test have been conducted three years from 1989. In the first year one variety and 19 strains were tested and among them several strains showed 1 ~ 25 t/ha. Almost all the strains which showed very poor yields suffered from soil acidity, deficiency of elements, surplus of soil moisture, and damage to black maize beetles, etc. resulting in no possible comparison between them.

In 1990, nine varieties, most of them recommended by the Ministry of Agriculture, were tested. The results were not so good even under the copper applied condition because the test was conducted on the soil with a muck layer thicker than 20 cm.

This year 1991, the variety test was conducted on the soil with muck layer thinner than 20 cm under the copper applied condition. The results of this year for the varieties sown on May showed better yields than the previous two years. It can be said that the varieties which showed better yields this year are considered to be suitable for cultivation in Namushakende when muck layer thinner than 20 cm, liming, and copper application are considered.

Concerning sowing date, after the harvest of early rice wheat can be sown after the middle of April, but as this year has shown, cold damage may occur at the booting stage, so that, it is better to delay sowing until early to middle May.

2) Cattle manure application trials in low acidic peat-muck soil containing sand (1990)

a) Materials and methods

Field:	Namushakende W-2 (Peat-muck low acidic soil containing sand)
Varieties:	Loerie I, Jupateco
Sowing date:	8th May (two varieties), 21st May (Jupateco)
Lime application:	1,500 kg/ha

Fertilizer:

i) Basal (N: 30 kg, P: 60 kg, K: 30 kg)/ha + cattle maure 4 t/ha

ii) Basal (N: 30, P: 60 kg, K: 30 kg)/ha + top dressing (60 kg/ha Urea)

Loerie I received $CuSO_4$ 15 kg/ha

Sowing method: Drilling with 0.25 m width level row
Seed rate 100 kg/ha

Plot size: Split plot with two replications, one plot 11 m x 5.5 m = 60.5 m^2 tested area 363 m^2

b) Results

The tests were conducted in the following three plots.

Plot [9] ($CuSO_4$ application)

In this field plant growth was almost normal although showing yellowish leaf tips during the middle stage. The results are shown in Table II.1.2.3. Manure applied plot showed earlier harvesting dates but had lower straw weights and grain yields than the controlled plots. the grain yield of the control plot was 2,480 kg/ha showing normal yield levels.

Plot [10] (No $CuSO_4$ application)

In the early growth stages copper deficiency symptoms were not as severe as in the variety test fields, but later on growth retardation occurred followed by sterile ears resulting in very low yields. In this field the plots with manure applications also has an earlier harvesting date but with a lower straw weight and a lower grain yield.

Plot [6] (No $CuSO_4$ application, late sowing)

In this field, although without $CuSO_4$ applications, copper deficiency symptoms were not severe showing almost normal growth, but because of many sterile ears the yield was low between 900 kg and 1,300 kg/ha. Here, manure application plots also has earlier harvesting dates but with better yields than the controlled plot differing from the above described two experiment plots ([9] and [10]).

The different effects of cattle manure on growth and yield between [9] · [10] and [6] may depend on the different depths of the peat-muck soil layer, there are about 20 cm in the [9] and [10] fields and about 7 cm in the [6] field. In cases where there is a thick peat-muck layer of soil like fields [9] and [10], cattle manure applications may give a minus effect because of the high organic matter, but in cases where there is a thin peat-muck layer of soil like field [6] it may cause the reverse good effect by adding the appropriate amount of organic matter.

3) Field operation trial for wheat (1990)

a) Objectives:

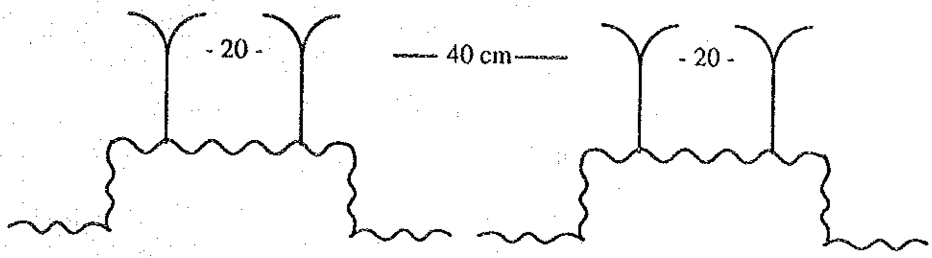
To investigate tillage methods applicable for wheat under high ground water level conditions after rice harvests.

b) Materials and methods

i) Ridging trial I

Field:	Namushakende M-2-(2)
Varieties:	Jupateco
Sowing date:	14th May
Sowing method:	• Level row drilling (0.25 m width) • Rough high ridge row drilling (0.2 m - 0.4 m - 0.2 m width) Seed rate 100 kg/ha

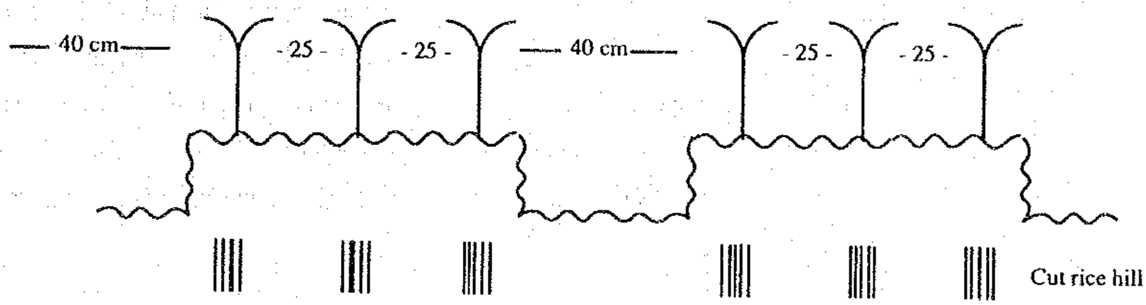
Roughly high ridge row drilling



ii) Ridging trial II

Field:	M-3-(1)
Variety:	Loerie II
Sowing date:	17th May
Sowing method:	• No tillage high ridge row drilling (0.4 m - 0.25 m - 0.25 m 3 row) Seed rate 100 kg/ha • Whole tillage high ridge row drilling

Whole tillage high ridge row drilling



Lime application:	1,500 kg/ha (common to trial I including fertilizer item)
Fertilizer:	Basal application; D'mix 300 kg/ha Top dressing; Urea 100 kg/ha (3 weeks after germination)

Plot size:	Trial I two replications each 10 m x 12 m = 120 m^2
	Trial II two replications each 9 m x 11 m = 99 m^2

c) Results and discussion

In trial I, the emergence and early stage growth of the level row plots was normal and good but in the rough high ridge plots because of the rapidly drying soil, emergence was very bad resulting in resowing and supplying water spraying. The field soil water content is shown in Table II.1.2.4 showing a lower water soil content in the high rough ridges than in the level row plots.

In trial II, both plots have three rows and the emergence of the central row was good but that of the other two rows running on both edge sides of the ridge were not so good because of the rapid soil drying of the edge part of the ridge.

Germination conditions in the early stage of growth level row plots were better than in the other plots.

After the middle stage copper deficiency symptoms also occurred in these fields and the yield was very low as shown in Table II.1.2.5. Although low level yield, in trial I level row plots showed better growth and yields than in the rough high ridge row plot. In trial II, because of extremely low level yield differences between the whole tillage field and the no tillage field under high ridge conditions can not be determined.

This year flood water levels were not high and the underground water level rapidly became low after the rice harvest. Under such conditions level rows are considered to obtain better results compared to the high ridge method because of superior conditions in keeping optimum soil water. In high ridge rows, the water supply from the base soil to the ridged up part may be cut resulting in an emergence disturbance.

In tillage operations, level rows are easier than high ridge row, so that, in cases of low underground water levels like this year it is better to proceed with level row operations. However, as may be expected, high underground water level conditions frequently occur, then high ridge row operation methods should be considered.

(2) Pulses

1) Trial in 1989

a) Objective:

To investigate adaptability of some pulses to muck-peat soils and climate in the cool dry season.

b) Materials and methods

Field:	W-2
Crops:	Chick pea (Cicer arietinum L.) Lentil (Lens esculenta MOENCH)
Sowing date:	14th April
Sowing method:	Ridge planting, two rows/ridge (0.3 m row width) 0.8 m between ridge, 0.3 m plant distance Seed rate for chick pea 40 kg/ha, for lentil 35 kg/ha
Fertilizer:	Lime application (1.5 t/ha) or no lime (No chemical fertilizer application)
Plot size:	0.8 m x 10 ridge x 8 m long = 80 m^2 (No replication)

c) Results and discussion

There were no large differences in emergence percentage and growth of young seedlings between the plots with and without lime applications. However, the difference of growth rates between plots became gradually apparent and 24 days after emergence, plants with lime applications were nearly twice the fresh weight compared with plants without lime applications as shown in Table II.1.2.6. In plots without lime applications, all the lentil plants died before flowering, while chick pea plants continued to grow and produced ripened grain as like the plants with lime applications.

The yields from both crops are indicated in Table II.1.2.7. Yield of lentil with lime applications was only 95 kg/ha which is less than one third of average yield in India. Yields of chick pea, on the other hand, were 515 kg/ha with and 284 kg/ha without lime application. The average yield for chick pea in India is 700 kg/ha. Yield of chick pea will increase to the level in India with the application of lime and chemical fertilizers. Chick pea may be more tolerant to acid soil and more adaptable to the conditions of these fields than lentil. Chick pea seems to be the promising pulse crop for protein foods in the cool dry season in the area.

2) Trial in 1991

a) Objectives

To study the suitable sowing density for chick pea which is considered to be suitable for Namushakende soil, and also to study the cultivation methods for lentil and soybean.

b) Materials and methods

i) Chick pea (Cicer arientinum L) and lentil (Lens esculenta Moench)

Field:	W-2-(2)
Varieties:	Local ones
Sowing date:	20th April
Liming:	1 t/ha, broadcasting
Fertilizer:	Basal; D'mix 200 kg/ha, row application

Sowing method:	Hill sowing with 30 cm row width, with three levels of hill distance 20 cm, 30 cm, and 40 cm, and 2 plants per hill
Plot size:	17 m^2 per plot, two replications

ii) Soybean

Field:	W-1-(2)
Varieties:	Gouxi 86, SJ-1, Paramate, IAC-2
Sowing date:	3rd May
Liming:	1 t/ha, broadcasting
Fertilizer:	Basal; D'mix 200 kg/ha, row application Top dressing; Urea 50 kg/ha
Sowing method:	Hill sowing with 60 cm row width, with 20 cm hill distance, 2 plants per hill
Plot size:	18 ~ 30 m^2 per plot, no replications

c) Results

Growth circumstances and yields of tested crops at the maturing stage are shown in Table II.1.2.8.

i) Chick pea

Emergence was good and growth was also better than previous year. There were no disease and insect damages, but some rats injuries were seen in shell and grain before the maturing stage. Among the sowing density plots, the most thick one with 20 cm hill distance of 16.7 hills per m^2 shows the best results. Yields of 30 cm hill distance plots were somewhat lower than that of 20 cm hill distance plots, and 40 cm hill distance plots showed considerably lower yields.

From this test, it is clear that optimum density for chick pea is about 15 hills per m^2 with two plants per hill. The maximum yield of this year with 560 kg/ha is almost three times of that of last year ('90) and 10% increase of that of the year before last ('89). This year's high yield may depend on earlier sowing date and higher planting density.

ii) Lentil

Emergency was normal and there were no remarkable occurrence of diseases and insects. However, similarly to last year growth was very slow showing plant weight representing one sixth to seventh of that of chick pea. Rat damage before the maturing period was little, but grain yield was very small similarly to stem and leaf weight showing 70 ~ 90 kg/ha. This yield was almost similar to that of the year before last and better than that of last year.

In spite of the small productivity, response to planting density was so small that no growth and yield difference between 20 cm hill distance plot and 30 cm hill distance were recorded. From this result lentil was considered to be unsuitable to Namushakende area.

iii) Soybean

Emergence was not so good in general as to be adjusted especially in Paramate and SJ-1 varieties by resowing. Growth circumstances were almost similar to that of last year giving short stem and pale leaf color owing to nitrogen deficiency. Maturing period was uneven even in the same variety, and in all the varieties many individuals were seen with earlier maturing shells while stems and leaves were still green.

Grain yields are low in general with 200 ~ 260 kg/ha and among varieties Paramate and SJ-1 are somewhat better. Low yields may be related to show growth caused by short day length and low temperature in June and July and also depend on restriction of grain setting by nitrogen deficiency caused by lack of root nodule.

d) Discussion including the results of the previous years

In cool dry season on peat-muck soil, chick pea and lentil were tested for three years and soybean for two years. From the results, as described above, it is clear that chick pea is the most suitable under the condition of soil acidity correction and securing of standing by dense sowing. Lentil is not suitable, but soybean may have possibility of getting more yield by varietal selection, inoculation of root nodule bacteria, and improvement of fertilizer application methods.

(3) Vegetables

1) Trial in 1989

To study the effects of lime application on yield of cabbage and onion in the cool dry season.

a) Materials and methods

Field:	W-2
Crops:	Cabbage (Local variety), Onion (Texas early grano 502)
Planting:	Sowing in nursery 24th February. Transplanting in field 13th April. Cabbage .... 0.6 m between ridge, 0.4 m plant distance. Onion .... 0.8 m between ridge, 2 row/ridge with 0.3 m row width and plant distance.
Fertilizer;	Basal .... D'mix 500 kg/ha + cow manure 3 kg/m^2 Lime application (1.5 t/ha) or no lime

b) Results and discussion

After transplanting, root occurred in some of the seedlings of both crops due to an excess in soil moisture caused by the rerising of ground water levels.

All cabbage head yields harvested were more than 60% higher in the plot with lime applications than in that without lime applications as shown in Table II.1.2.9. Moreover, weight percentage of large head (more than 1 kg in weight) was 55% in the plot with lime application and only 5% having edge rot on the leaves (symptom of calcium deficiency) in the plot without lime applications.

All onion bulb yields harvested were 8.2 t/ha with and 4.9 t without lime application (Table II.1.2.10). The weight percentage of large bulb (more than 7 cm in diameter) was 36% with and 24% without lime application.

The average yields of cabbage and onion in Zambia are 28 t/ha and 25 t/ha, respectively. Cabbage yield in this trial was comparable with the country's average, but onion yield was only one third of the country's average. Onion may be more susceptible to acidity and nutrient disorder derived from muck soil than cabbage. Cabbage is expected to be one of hopeful vegetable crops produced in the cool dry season in the area. Further investigations will be necessary on the cultural practices of onion as well as for cabbage.

2) Trial in 1991

a) Objectives

To study stable cultural methods for cabbage.

b) Materials and methods

Field: W-2-(2)

Varieties: C. H. Market

Sowing date on nursery bed:	21st March
Transplanting date:	23rd April, 30th April
Liming:	1 t/ha, broadcasting
Fertilizer:	Basal; Heavy (D'mix 500 kg/ha), row application Little (D'mix 300 kg/ha), row application Universal for whole plots (Cattle manure 1.2 t/ha) Top dressing; for whole plots (Urea 85 kg/ha)
Planting density:	60 cm width between row, 35 cm hill distance
Chemicals:	Three times insect control (Sumithione 1,000 times liquid)
Plot size:	50 m^2 per plot, no replications

c) Results and discussion including the results of the previous years

According to the delay on sowing in nursery and also to the mite damage, growth of seedlings were uneven. From these conditions, transplanting was divided into 2 periods considering the seedling size. Rooting was good after transplanting, and self-topping was controlled by chemical spray. Harvesting was done from 16th to 30th August, and the results are shown in Table II.1.2.11.

Total weight of heads differs depending on the amount of basal fertilizer applied showing 21.6 t/ha in plots supplied with light doses and 35.5 t/ha in plots with heavy doses. In these latter plots heavier weight per head and higher percentage of head number per total number of planted seedlings were recorded.

This year, plots which received heavy doses of fertilizer gave considerably higher yield compared with that of the last two years exceeding 27% of the national yield which stands at 28 t/ha. As described before for this year, owing to the small size of seedlings and delay in transplanting date, individual heads were small. However, higher yield was gained by getting higher percentage of head number per transplanted seedlings owing to self-toping control by chemicals and higher transplanting density. The above mentioned methods, including soil acidity correction, can be said as the stable cultivation techniques for cabbage in peat-muck soil area.

Furthermore, from past year trials, it can be said that more nitrogen application is related to high cabbage yield.

Table II.1.2.1 Growth and Yield of Wheat Varieties Sown in April 1991

(Sown on 19th April 1991)

Varieties	Heading Date	Maturing Date	Culm Length cm	Straw Weight t/ha	Grain Yield t/ha
Loerie I	26-Jun	17-Aug	57	1.74	0.13
Loerie II	17-Jun	11-Aug	59	2.30	0.02
Coucal	20-Jun	12-Aug	82	1.95	0.33
J 130	26-Jun	20-Aug	57	2.30	0.03
Jupateco	18-Jun	18-Aug	55	2.43	0.12
Whydah	30-Jun	16-Aug	85	2.18	0.27
Canary	23-Jun	15-Aug	52	1.67	0.18
Emu	17-Jun	17-Aug	53	2.00	0.22

Note : Low yield of this experiment depends on cold damage caused by minimum 2℃ temperature on 4th June.

Table II.1.2.2 Growth and Yield of Wheat Varieties Sown in May 1991

(Sown on 10th May 1991)

Varieties	Heading Date	Maturing Date	Culm Length cm	Straw Weight t/ha	Grain Yield t/ha	Significant difference w/r to Jupateco	Significant difference w/r to Loerie II
Loerie I	22-Jul	10-Sep	58	1.74	1.83	**	*
Loerie II	22-Jul	10-Sep	58	2.02	2.34	not	-
Coucal	28-Jul	10-Sep	93	2.57	2.11	not	not
J 130	23-Jul	11-Sep	60	2.11	2.21	not	not
Jupateco	16-Jul	9-Sep	62	2.02	2.50	-	not
Whydah	31-Jul	11-Sep	97	2.87	1.83	**	*
Canary	19-Jul	10-Sep	57	1.72	1.93	*	*

Note : Significant 5% level 40.4kg
Significant 1% level 56.7kg

Table II.1.2.3 Cattle Manure Application Trials in Low Acidic Peat-muck Soil Containing Sand for Wheat (1990)

No. of Field	Varieties	Treatment: Sowing date	Treatment: CuSo4 kg/ha	Treatment: Manure t/ha	Date of Maturity	Culm Length cm	Straw Weight kg/ha	Grain Yield kg/ha
[9]	Loerie I	Early sowing	10	4	26/8	63	1,488	2,112
	〃	〃	10	0	9/10	50	1,832	2,480
[10]	Jupateco	Early sowing	0	4	12/9	41	588	132
	〃	〃	0	0	15/9	48	1,388	280
[6]	Jupateco	Late sowing	0	4	12/9	58	1,918	1,302
	〃	〃	0	0	19/9	55	1,857	900

Table II.1.2.4 The Effect of Tillage Methods on Soil Surface Layer (2-5 cm) Water Content (1990)

Tillage method	Soil water contnet	Measured date
Whole tillage level row	44.0	May 26 (12 days after sowing)
Rough high ridge row	36.2	〃

Table II.1.2.5 Effect of Tillage Methods on Wheat Growth and Yield

Trial I

Tillage method	Date of Maturity	Culm Length cm	No. of Ears /2m	Straw Weigth kg/ha	Grain Yield kg/ha
Whole tillage level row	18th Sept.	44	138	804	342
Rough high ridge row	21st Sept.	38	124	560	128

Trial II

Tillage method	Date of Maturity	Culm Length cm	Straw Weigth kg/ha	Grain Yield kg/ha
Rough high ridge row	15th Sept.	37	334	30
Whole tillage high ridge row	19th Sept.	36	307	25

Table II.1.2.6 Growth of Seedlings of Pulse Crops

(24 days after emergence)

Items / Treatment	Fresh Weigth (per 50 plants/gr)	Soil pH
Lentil		
Without lime	6.45	3.9
With lime	13.65	5.1
Chick pea		
Without lime	29.21	4.3
With lime	51.67	5.6

Table II.1.2.7 Pulses Yield

Treatment / Crops	Yield kg/ha	Plant height cm	No.of branches
Chick pea			
With lime	514.5	31.4	21.3
Without lime	284.4	29.1	8.5
Lentil			
With lime	95.5	19.5	-
Without lime	-	-	-

Table II.1.2.8 Growth and Yield of Pulses (1991)

Crops	Planting Density Hill Distance cm	Maturing Date	Stem Length cm	Stem and Leaf Weight kg/ha	Grain Yield kg/ha	Ratio to 30 cm Hill Distance Plot %
Chick pea	20	Sept.26	35	920	563	104
	30	Sept.26	38	830	539	100
	40	Sept.26	38	870	466	86
Lentil	20	Sept.25	25	140	89	101
	30	Sept.25	25	130	88	100
	40	Sept.25	27	90	67	76
Soybean	Varieties					
	IAC-2	Sept.26	50	390	194	
	Paramate	Sept.20	33	270	262	
	SJ-1	Sept.20	31	250	244	
	Gouxi 86	Sept.26	35	150	199	

Table II.1.2.11 Yield of Cabbage (1991)

Amount of Applied D'mix Fertilizer kg/ha	Total Heads Weight t/ha	Percentage of Harvested Heads Number over Planed Seeding Number %	Percentage Weight over 700g Heads %
300	21.6	75	26.4
500	35.5	80	68.9

Table II.1.2.9 Cabbage Yield by Head Weight (1989)

Grade of Head Weight	With lime				Without lime			
	Whole Yield - - - - 22.2 t/ha				Whole Yield - - - - 13.4 t/ha			
	Average Weight of a Head (kg)	Average Diameter of a Head (cm)	Percentage of Head Weight	Percentage of No.of Heads	Average Weight of a Head (kg)	Average Diameter of a Head (cm)	Percentage of Head Weight	Percentage of No.of Heads
LL (>1.8kg)	1.81	14.0	3.0	1.7	-	-	0.0	0.0
L (1.1kg-1.8kg)	1.30	12.3	52.1	40.0	1.33	12.8	11.0	5.1
M (0.8kg-1.1kg)	0.96	10.4	19.1	20.0	0.89	10.7	14.7	10.2
S (0.7kg-0.8kg)	0.75	9.2	10.1	13.3	0.76	10.1	18.9	15.3
SS (<0.7kg)	0.63	8.4	15.7	25.0	0.49	7.9	55.4	69.4

Table II.1.2.10 Onion Yield by Bulb Diameter

Grade of Head Weight	With lime				Without lime			
	Whole Yield - - - - 8.2 t/ha				Whole Yield - - - - 4.9 t/ha			
	Average Weight of a Head (kg)	Average Diameter of a Head (cm)	Percentage of Head Weight	Percentage of No.of Heads	Average Weight of a Head (kg)	Average Diameter of a Head (cm)	Percentage of Head Weight	Percentage of No.of Heads
LL (>9cm)	0.22	12.0	2.7	1.6	-	-	0.0	0.0
L (7cm-9cm)	0.25	8.1	33.8	18.2	0.24	7.8	24.9	10.9
M (6cm-7cm)	0.17	6.8	26.3	20.7	0.16	6.6	42.8	27.2
S (5cm-6cm)	0.13	5.9	19.9	20.7	0.14	5.9	13.4	9.8
SS (<5cm)	0.06	3.9	17.3	38.8	0.14	3.8	18.9	52.1