The change of the moisture ratio resulted in a contradictory fluctuation depending on the soil type. The CBC at a 5 cm depth in peat muck soil decreased gradually as the rainy season progressed and finally agreed with CBC at a 15 cm depth. On the other hand, the CBC of the sandy soil at 5, 10 and 15 cm depth fluctuated in parallel even after flooding with a range of 2-9 kg/cm^2 from 5 to 15 cm depth. Conclusively, the lower layer of the peat-muck soil remains wet even if the surface layer is desiccated, sharply reducing the CBC from top to bottom, while the sandy soil considerably maintains its CBC even in flooded conditions. Based on these results, it was concluded that oxen plowing operations would be difficult all year round in fields thickly distributed with peat muck soils which drain poorly, but possible in sandy soils even in flooded condition.

2.1.2 Upland Crops in the Cool Dry Season

For cool dry season upland crops the following crops were studied:

Cereals:	Wheat
Beans:	Chickpea, Lentil
Vegetables:	Onion, Cabbage

In the Western province, the cool dry season is from May to August with an average mean monthly temperature ranging from 17°C to 30°C. Considering this temperature environment the above mentioned crops were considered to be suitable for this season.

Among the beans, chickpea showed somewhat good yields, but in general, beans did not yield so much resulting to the conclusion, at present, that it is difficult to introduce beans into the farming practices.

Important points concerning the promising crops will be described in the following:

(1) Cultivation techniques for wheat

Wheat has a relatively wide adaptability to various environmental conditions, and is cultivated as a cool dry season crop in Zambia. In the fertile area (See section 1.1.1 "Natural Environment" at sub point 1) "Fersiallitic soils" under point (3) "Soils and vegetation", wheat is cultivated under sprinkler irrigation by

commercial farmers and involved an area of about 7,000 ha in 1988 and yields exceeding 4 t/ha (Table 1.1.3). However, this fertile area is restricted (Fig. 1.1.5). The rainfed wheat cultivated area was about 360 ha in 1989/1990 with only a production of about 330 t and a large part of the production (about 99%) coming from the Northern province (Appendix Table I.1.7.) and only cultivation tests have been done in the Western province. The consumption of wheat is considered to increase in the future.

The cultivation techniques for wheat on the edge of the flood plain of the Zambezi river with peat-muck soil were examined as component technology for double cropping crops after early rice.

1) Selection of varieties

Eight varieties collected in Zambia were tested for their suitability in the area. The testing conditions were as follows; the sowing date was 10th May with 80 kg/ha seeding rate, drilling 25 cm width. Because of acidity and micronutrient deficiency found in the peat-muck soil, lime and copper sulfate were applied.

All the tested varieties matured around 10th September. As shown in Table 2.1.4, the yields ranged from 1.83 to 2.50 t/ha, and half of the tested varieties yielded more than 2 t/ha. There were no significant differences among the high ranking four varieties, Jupateco, Loerie II, J130, and Coucal, showing the suitability of these varieties to peat-muck soil. Among these, Jupateco and Loerie showed significantly higher yields than the lower ranking varieties, Canary, Loerie I, and Whydah.

The next test started on 19th April, and showed severe chilling damages on young panicles caused by the abnormally low temperatures which reached 2°C on 9th June, and resulting in very low fertility. Considering the possible occurrence of such abnormally low temperatures, sowing before the middle of April must be carefully considered.

Table 2.1.4 Varietal Test of Wheat in Muck Soil (1991)

Varieties	Maturation date	Culm length	Grain yield	Straw weight	Varietal differences in grain yields and their significance level		
		cm	t/ha	t/ha	Jupateco	Loeric II	J130
Jupateco	Sept. 9	62	2.50	2.02	-	-	-
Loeric II	Sept. 10	58	2.34	2.02	16	-	-
J130	Sept. 11	60	2.21	2.11	29	13	-
Coucal	Sept. 10	93	2.11	2.57	39	23	10
Canary	Sept. 10	57	1.98	1.72	51*	41*	28
Locric I	Sept. 10	58	1.83	1.74	67**	51*	38
Whydah	Sept. 11	97	1.83	2.87	67**	51*	38

Note) Significance level of yields: *5% 40.4 kg/ha, ** 1% 56.7 kg/ha

2) Fertilizer application method

In the muck soil, N, P and K applications for wheat were examined. Under uniform conditions the application of 1 t/ha of lime and 30 kg/ha of $CuSO_4$, eight different application methods of N, P, K were carried out with the Loeric II variety sown on 29th April.

As shown in Table 2.1.5, non fertilized plots and PK(-N) plots clearly show poorer growth than NPK plots and only 41-42% (1% significant) of the yield in the latter plots. Although not significant, NK(-P) plots were lower than NPK plots with 79% of the yield. NP(-K) plots showed no difference with NPK plots. There were no effects with the increased dosage of P and K.

In the muck soils it is estimated that as shown in this trial the amount of nitrogen released from the soil is so insignificant that the growth of wheat under non fertilized conditions is greatly affected. Therefore, in wheat cultivation nitrogen is the most important element followed by phosphate.

The trial suggests that the application of D'mix 300 kg/ha as a base and urea 100~200 kg/ha as a top dressing will provide an adequate supply of nitrogen. In addition, lime of 1~1.5 t/ha for acidity amendment and copper sulfate of 30 kg/ha copper deficiency countermeasures should be applied.

Table 2.1.5 Growth and Yields of Wheat depending on Fertilizer Application Methods

Fertilizing conditions		Culm length	Straw weight	Grain yield	Significance to NPK+N plot	1,000 grain weight
Basal	Topdressing	cm	t/ha	t/ha		g
0	+	46	0.77	0.66	**	38.3
PK	+	46	0.80	0.67	**	39.3
NK	+ N	55	1.32	1.26		37.7
NP	+ N	52	1.26	1.64		36.0
NPK	+ N	54	1.33	1.59	-	41.0
NP2K	+ N	54	1.48	1.63		39.7
NPK2	+ N	55	1.72	1.50		42.0
NP2K2	+ N	54	1.27	1.43		43.4

Note) Application amount of NPK+N plot: Basal 30-60-30 kg/ha + Topdressing of 40 kg N
(unit : each element kg/ha)
Significance level of yields: *5% 47.2 kg/ha, **1% 65.6 kg/ha

3) Countermeasures for the copper deficiency of wheat

The peat-muck soil area surrounding Namushakende is acidic and likely to cause copper deficiencies in wheat with white colored and twisted top leaves, followed by many sterile ears with almost no yield at all in severe cases. As shown in Table 2.1.6 this symptom is considered as a copper deficiency. To study copper deficiency countermeasures in 1991, copper sulfate application trials were conducted. The increased volume of copper sulfate with each plot soil was uniformly broadcasted and mixed with the surface soils before sowing seeds. Other methods of cultivation were similar to the fertilizer application trials.

No Cu application plots showed copper deficiency symptoms from the middle stage resulting in many of sterile ears, but Cu applied plots showed no symptoms, although some excess damage associated with growth retardation were observed in $CuSO_4$ 45 kg/ha plots, but not in the 15 or 30 kg/ha plots. Grain yields of no Cu plots in the Loerie II and Coucal were clearly lower than that in the 30 kg/ha applied plots, and only 17 and 67 % of the $CuSO_4$ treated plot respectively. Among Cu applied plots, 30 kg/ha plots yielded the most followed by the 15 kg/ha plots, and 45 kg/ha plots showed excess injury (Table 2.1.7). Among the varieties Coucal seemed to be more resistant; however, in the peat-muck soils it is essential to apply

copper in wheat cultivation at an optimal rate of 20 ~ 30 kg/ha as copper sulfate ($CuSO_4$).

The application method of small quantity of $CuSO_4$ requires a gradual increase of the volume by mixing with upland soil and a uniform broadcast over the surface soil at the time of sowing preparation. In the case of nonuniform applications excess injury may occur.

Cu deficiency as related to soil type was investigated by using various soils sampled from various areas surrounding Namushakende. The soil containing silt with a relatively low level of acidity showed rather slight deficiencies. The details of the trials were presented in the 1992 AVS Report.

Table 2.1.6 Mineral Content of Wheat Affected by Copper Deficiency (1991)

Fields	Variety	Amount of $CuSO_4$	N	P	K	Ca	Mg	Zn	Fe	Mn	Cu	B
		kg/ha	%	%	%	%	%	ppm	ppm	ppm	ppm	ppm
A	Coucal	15	1.19	0.25	0.66	0.26	0.20	14.5	147	84	10	2.5
A	Coucal	0	1.19	0.22	0.65	0.32	0.18	10.3	157	114	2	3.7
B	Loerie I	15	1.19	0.20	0.94	0.23	0.12	20.8	165	38	20	1.5
B	Loerie I	0	2.18	0.39	1.07	0.33	0.21	17.9	124	138	6	2.4

(Analyzed by Mount Makulu Central Research Station)

Table 2.1.7 Effect of $CuSO_4$ in Wheat (1991)

Variety	Amount of $CuSO_4$	Straw weight	Grain yield	Level of significance		L.S.D.
	kg/ha	t/ha	t/ha	0 plot	45 kg plot	
Loerie II	0	1.03	0.22	-		
	15	1.58	1.16	*		5% level 69 kg <
	30	1.96	1.35	**		1% level 105 kg <
	45	1.93	1.02	*	-	
Coucal	0	1.96	1.39	-		
	15	2.55	1.81	*	*	5% level 39 kg <
	30	3.49	2.07	**	**	1% level 59 kg <
	45	2.04	1.33		-	

(2) Cultivation techniques for onion

The production of onion in the Western Province is quite few and can only be seen in some farmers' fields where it is grown for local consumption. The total production amounts only to 250 tons in the Province, and high demand compensates for shortage by importing from Lusaka.

The optimum temperature for onion growth ranges from 10 to 25°C and cultivation is relatively easy with few pests and diseases. Also there is the advantage for long preservation and easy transportation. With these considerations, the introduction of onion for double cropping with early rice was studied.

The results of 1990 trials were as follows; nursery started on 11th March, followed by transplanting on 8th May and harvest on 11th September. Yields of onion bulb differed depending on fertilizer conditions, and the size of the seedlings, and resulted in 17.7 t/ha (normal seedlings) and 8.1 t/ha (small seedlings) without cattle manure, and 28.0 t/ha (normal seedlings) and 20.0 t/ha (small seedlings) with cattle manure. From these results it was clear that cattle manure and the size of the seedlings were very important.

The average of the onion yield in Zambia in the rainy season is about 25 t/ha. The yield under cattle manure and normal seedlings described above was similar to this value thus suggesting the possibility of onion cultivation in the muck soil area surrounding Namushakende.

In case of excess soil moisture, white leaf spot (Phytophthora porri Foister) occurs. Therefore, poorly drained fields with thick peat-muck layers should be avoided.

Concerning the varieties used in the verification study only one could be obtained locally. Apart from this variety, Yellow Premium suitable for January-April and August-December sowing pusa red and Henry's special yellowgranex F_1 suitable for May-July sowing are the recommended varieties in Zambia. These varieties should be tested in the muck soils of the Namushakende area for their adaptability. Concerning the planting density, the verification study experimented with 16.7 plants/m^2, but about 25~30 plants/m^2 appeared to be much better.

Table 2.1.8 Results of Onion Trials (1990)

Trial conditions	No. of bulbs (x 100/ha)			Weight of bulbs (t/ha)		
	Large	Small	Total	Large	Small	Total
Cattle manure						
Normal seedling plots	1,410	168	1,578	26.9	1.1	28.0
Small seedling plots	1,057	488	1,545	17.7	2.3	20.0
Average	1,234	328	1,562	22.3	1.7	24.0
Non cattle manure						
Normal seedling plots	840	640	1,480	14.8	2.9	17.7
Small seedling plots	319	1,125	1,444	4.2	3.9	8.1
Average	580	883	1,463	9.5	3.4	12.9

Note) Variety; Texas early yellowgrano 502
Fertilizer application conditions
Cattle manure plot; Basal 500 kg/ha D'mix, Dried cattle manure 3 t/ha, Lime 1.5 t/ha
Non cattle manure plot: Basal 500 kg/ha D'mix, Lime 1.5 t/ha
Topdressing 100 kg/ha Urea
(50 kg at 3 weeks and 6 weeks after transplanting respectively)

(3) Cultivation techniques for cabbage

Similarly to onion, cabbage is also cultivated only by a few farmers. However, its consumption is gradually increasing and as a result, the ones introduced from Lusaka are sold at relatively high prices requiring the expansion of local production.

Cabbage is suitable in cool temperatures (15 - 20°C), having a relatively short growth period with easy transportation and storable adaptability. In the Western province night temperatures are cool from April to August and there is relatively enough water until July in the Sishanjo area. With these considerations in mind, cabbage could be cropped followed by early rice and its cultivation method has been investigated.

Based on the past 2 years trials, it was clear that the amendment of acidity to values higher than pH 5.5, and the Control of Heelula undalis fabricius were essential. Based on these data the trial in 1991 was conducted under the following conditions: the variety was C.H. Market; sown in the nursery on 21st March; transplanted on 23rd April with 0.6 m of row space and 0.35 m of hill space; insect control with Sumithione of 1,000 times liquid, three times spray in the nursery. The fertilizer application conditions and yields are shown in Table 2.1.9.

The total weight of yielded bulbs depended on the amount of basal fertilizer, as 21.6 ton/ha with light doses and 35.4 ton/ha with heavy doses. These good yields depended also on acidic amendments, high planting densities, and pest control to protect against self-topping. The pest control should be considered to minimize chemical application. For muck soils, it is desirable to select an area where the muck layer is less than 20 cm deep, otherwise the soil will generally show a high acidity with poor drainage conditions and not suitable for cabbage.

Table 2.1.9 Yields of Cabbage (t/ha)

Year	1990		1991	
Plots	Liming	Non liming	Low dosage	High dosage
Weight of bulbs	22.2	13.4	21.6	35.5

Note) 1990; Liming plot 1 t/ha
1991; Lime was dressed 1 t/ha in every plot
Low dosage; Basal D'mix 300 kg/ha, Cattle manure 1.2 t/ha, Topdressing urea 80 kg/ha
Heavy dosage; Basal D'mix 500 kg/ha, Cattle manure 1.2 t/ha, Topdressing urea 80 kg/ha

2.1.3 Upland Crops in the Hot Dry Season

The following crops were tested to select suitable crops for the late rice-hot dry season crop farming systems:

Cereals:	Maize, Sorghum, Pearl millet
Pulses:	Cowpea, Contender bean, Bambara bean, Groundnut, Soybean
Root crops:	Irish potato, Sweet potato
Vegetables:	Tomato, Sweet corn

The growth period for the hot dry season crops is limited to about 125 days from early August to early December, for climatic condition, particularly by temperature and rainfall distribution, and wet conditions in the field. It is, therefore, most important to set the following as criteria for crop selection:

- A period of less than 125 days from seeding or planting until the harvest season;
- High yielding crops or highly profitable crops;

The results of the past 3 year trials showed maize and tomato to have met the criteria. Sweet corn was also considered as a promising crop although it is only presently cultivated in particular areas.

Sorghum, which has a growth period almost similar to maize, is inferior to maize as it has a lower yield and suffers numerous bird damages.

There are very early maturing pearl millet varieties having a growth period of less than 100 days. These varieties can be used as substitutes for maize if seeding is impossible till late August due to land conditions. The crop, however, produces low yields and is usually damaged by birds.

Cowpea, Bambara bean, Groundnut, and sweet potato were considered unsuitable because of their very long growth periods, while contender bean, soybean and irish potato were considered unprofitable because of their low yield.

(1) Maize

Maize is the staple food and one of the most important agricultural product of Zambia. Maize is consumed in various ways.

The main maize producing provinces in Zambia are the Southern, Central and Eastern Provinces, while only 30,000 ha of land, 4% of the overall land area nationwide, in the Western Province is cultivated with maize. However, maize covers more areas in the Western Province in comparison with other cultivated agricultural products, and is ranked along with rice as the most important agricultural product in the region.

The results of the 3 year trial concluded the following maize cultivation methods for the establishment of the double cropping system of late rice and maize.

1) Varieties

The main varieties recommended in Zambia are shown in Table II.1.10 (cited from Commercial Crop Production Recommendations, Belgian Aid Programme to Zambia, 1987).

As maize is generally seeded in the later days of the dry season when slight rainfall is observed, the varieties used mostly hold characteristics suitable to the rainy season. Therefore, the varieties suitable for the double cropping system in the dry season are very limited.

Late rice and maize double cropping system requires a growth period of less than 120 - 125 days. Therefore, seeding must be conducted in the 1st half of August and harvesting before the 10th of December. The high yielding and resistance to disease characteristics of varieties are irrelevant if the growth period differs.

The total growth period of the recommended varieties, which was based on data for traditional cropping systems, exceeds 130 days. The study, however, has proven that most varieties cultivated in the dry season, between August and December, mature 20 days earlier than those cultivated in the traditional cropping season (see Table 2.1.11). The introduction of the MM500 series' is judged to be possible in this cropping system.

The results of the comparative study on varieties are shown in Table 2.1.12.

The following conclusions were reached according to the results of the 3 year-trial.

a) It is impossible to use the varieties of the MMV600 and MM700 series' for the double cropping system in spite of their high yielding characteristics, because of their long growth periods;

b) Although the MM500 series can be used if seeding is possible before the 15th of August, confirmations on which variety (MM501, MM502, MM504) is most suitable has not been made. It has been conjectured, however, that MM502 comparatively excels because of its yield potential and its high resistance to the streak virus;

2) Points of concern on maize cultivation

a) Planting rate

The Belgian Aid Program to Zambia recommends that a planting rate of 40,000 - 50,000 stocks/ha is most appropriate for the MM500 series. On the other hand, due to labor shortages, an experiment was instead conducted on an 80 cm wide ridge having a stock interval of 30 cm (accommodating 41,666 stocks/ha). Based on the growth of the stem and the leaves, however, it was concluded that 50,000 stocks/ha, that is a stock interval of 25 cm, would be a lot more productive.

b) Fertilizer amount

The standard amount of fertilizer used in the verification study was 300 kg of D'mix (compound fertilizer, 10-20-10) for a basal application, 100 kg of urea for a top dressing (76 kg of nitrogen, 60 kg of phosphate, 30 kg of potash) per hectare. This practice attracted criticism from some local engineers. However, since maize absorbs a lot of soil nutrients, it is necessary to supply the amount of nutrients required. For example, 100 kg of nitrogen, 18 kg of phosphoric acid, and 68 kg of potassium absorbed for 4 t/ha of grain yield results in the decrease in soil fertility. It is, therefore, necessary to increase the amount of fertilizer to be applied (see Table 2.1.13).

c) Control of diseases, pests and rodents

The occurrence of disease and insect pest is generally very small in the dry season, and apart from the maize stalk borer (Busseola Fusca), problems hardly ever exist. Damages caused by the maize stalk borer can be prevented by spraying Sumicidin twice, two and four weeks after germination of maize. On the other hand, damages inflicted by rodents to the seed before germination and to the seedlings after germination is very severe in the dry season. The use of traditional rat traps and imported rodenticides (i.e. Desmoa), therefore, are very necessary. In small fields, the use of 30 cm wide corrugated plastic fences surrounding the field and the application of rodenticides outside the fence are also countermeasures to prevent rodents.

d) Drainage

Although rainfall patterns vary annually, the field can get flooded due to torrential downpours after late November. Drainage facilities are, therefore necessary.

(2) Tomato

Tomato is one of the most important vegetable in Zambia and is a major commodity in the metropolitan and local city fresh markets. The cultivation of tomatoes compared with other crops is intensively conducted in terms of fertilizer application, support construction and irrigation in periods with little rain. Debudding is generally not carried out as the total production is large even with small fruits. Most of the fruits are harvested and marketed at their unripened stage due to the lack of preservation facilities and due to their demand as cooking ingredient.

The results of the trial concluded the following tomato cultivation methods for the double cropping of late paddy and tomatoes.

1) Varieties

It is impossible to discuss suitable varieties as only two were tested; the Zambian Red Kaki variety and the Japanese Magokoro variety. To include it in the cropping system of late paddy and tomatoes, the final transplanting

should be made after the 1st half of August and harvest up until the 10th of December. Further, to extend the growth period, high yielding early ripening varieties are required. The Magokoro variety is very suited to the double cropping system as it can be harvested a week earlier than the Red Kaki variety. Zambians claim, however, that the taste of the produce is not as acidic as it should be. The debudding of Red Kaki, however, not only produces a weight of approximately 20% per fruit, but also hastens the harvest season to a week earlier. It is, therefore, necessary to prolong the harvest period of Red Kaki by early transplanting and debudding until suitable early growing varieties are found (see Table 2.1.14).

2) Points of concern on tomato cultivation

a) Early seeding and transplanting

As previously mentioned, the prolongation of the harvest period of tomatoes would require early transplanting. In the actual experiment, the earliest transplanting work was conducted in the later days of August. Therefore, the maximum yield gained was only 22 t/ha, as harvest was conducted for only less than a month (see Table 2.1.15).

If transplanting was carried out a month earlier, the amount of yield would have increased remarkably. This would, however, require seeding in nursery beds in early July and planning for low temperature problems. Generally, tomato seedlings require a daily minimum temperature of more than 10°C , and a successive daily minimum temperature of 6 - 7°C slow down the growth process. Transplanting is possible 30 days after if the growth process is normal, but would be difficult under abnormal circumstances unless it is conducted 40 days after. Based on the past temperature data of Mongu, it is highly probable that the growth of seedlings in open fields seeded in early July would be delayed. Transplanting, therefore, shall be conducted in the middle of August and the harvest period will be half a month longer than the experiment period given. Heat insulation measures, such as vinyl tunnel culture or the covering with straw mats at night, will prevent growth stagnation and enable fixed transplanting in early August.

b) Amount of fertilizer application

During the experiment, only a small amount of fertilizer was requested, and because the amount of fertilizer was very limited, the yield was also comparatively low. To gain a much larger profit, the amount of fertilizer should be increased.

The standard amount of fertilizer applied in Japan per hectare is 300-150-220 kg of nitrogen-phosphate-potassium. In the experiment, only 60-120-60 kg of nitrogen-phosphate-potash was used. Considering the market price of tomatoes, the average of both values was considered more appropriate. In Senegal, a similar study showed that the amount of fertilizer used was 210-150-160 kg/ha.

c) Control of diseases and insects

Chemical spraying is hardly ever conducted in the dry season as there are very few diseases and insect pests. During the experiment, acaricide was only sprayed once to obstruct damages caused by Red Spidermites (Tetranychus spp.). Red Spidermites, which cause minor damages, usually have outbreaks in the middle of October when all the other insects are under control due to the hot dry temperatures. Armyworms can also be found within the fruit and can be eliminated through the spraying of Sumition.

(3) Sweet corn

Sweet corn is currently being cultivated only in few Zambian districts. The experimental results show that it can be cultivated in lieu of maize if suitable seeding is not possible for the latter, because it has a good taste and a short growth period. Further, to evade growth retardation by the continuous cropping of tomato, sweet corn is expected to be a rotation crop with tomato. (see Table 2.1.16)

1) Varieties

The experiment indicated Honeybantam 20 as a good variety. Honeybantam 9 and Canadian Rokky 77 were also considered to be promising varieties.

2) Points of concern for sweet corn cultivation

a) Seeding time

Sweet corn has a wide suitable seeding time from early August to 20th of September because its growth period is only 85 days. However, since there is very little rain from August till the middle of September, those seeded in early September are bound to undergo growth damages, resulting in low yield productions. Accordingly, the 20th of September is considered to be most appropriate time for seeding. It is also suggested to conduct a little irrigation in the middle of September.

b) Planting rate

Although the experiments employed the same measurements used for maize (80 cm wide ridge, 30 cm stock interval, approximately 41,700 stocks/ha, a 70 cm wide ridge and a 25 cm stock interval (approximately 57,000 stocks/ha) is considered more appropriate.

c) Application amount of fertilizer

Basal applications should be considered as important and top dressings should be applied early, as sweet corn grows fast and has a strong nutrient absorption ability. The required amount of fertilizer should be at least 800 kg/ha of D'mix for basal applications and 100 kg/ha of urea for top dressing.

d) Control of diseases and insects

The control of the Maize Stalk Borer (Busseola Fusca) is necessary as it can cause 30-40% crop damage (no. of damaged cobs/no. of harvested cobs). This can be sufficiently achieved by spraying Sumicidin twice, on the 2nd and 4th week after germination.

Table 2.1.10 The Recommended Maize Varieties of Zambia

Variety	Type[1]	Yield potential t/ha	Resistance[3] to			
			S.V.[2]	Rust	Blight	Cob rot
MM 501	SC	6.0	M	M	M	M
MM 502	SC	7.5	H	M	M	M
MM 504	TC	6.5	M	M	M	M
MM 601	SC	7.5	M	M	M	M
MM 603	TC	7.0	H	M	M	M
MM 604	TC	7.0	H	M	M	M
MM 752	SC	8.0	S	M	M	M

1) SC: Single cross, TC: Three way cross

2) S.V.: Streak virus

3) H: Highly resistant, M: Moderately resistant, S: Susceptible

Table 2.1.11 Growing Period of Main Recommended Varieties

Variety	Number of days from seeding to harvest	
	Recommendation by Belgian Aid	Result in Namushakende
MM 501	130 – 135	115 – 125
MM 502	140 – 145	115 – 125
MM 504	135 – 140	120 – 125
MM 601	140 – 145	
MM 603	145 – 150	125 – 135
MM 604	145 – 150	125 – 135
MM 752	155 – 160	
MMV400		110 – 120
Pool 16		105 – 115

Table 2.1.12 Results of the Verification Study

Variety	Seeding of Aug. 7th [1]		Seeding of Aug. 21st [1]		Seeding of Aug. 16th [2]	
	Maturing date	Yield [3] t/ha	Maturing date	Yield [4] t/ha	Maturing date	Yield t/ha
MM 501	Dec. 8th	2.97 b [5]	Dec. 15th	4.15 a [5]		
MM 502	Dec. 10th	3.59 a	Dec. 15th	3.88 a		
MM 504	Dec. 10th	3.25 ab	Dec. 18th	3.49 a	Dec. 11th	6.30
MMV400	Dec. 5th	1.93 c	Dec. 10th	2.30 b		
Pool 16	Dec. 1st	1.52 c	Dec. 5th	1.82 b		

1) The study was carried out at the farm in the Namushakende Farmer's Institute

2) The study was carried out at the Lealui farm

3) $LSD_{0.01}$ = 934 kg/ha, $LSD_{0.05}$ = 606 kg/ha

4) $LSD_{0.01}$ = 1232 kg/ha, $LSD_{0.01}$ = 858 kg/ha

5) The same letter in the same column shows no significant difference

Table 2.1.13 Nutrient Absorption of Maize

Part of plant	Yield t/ha	Contents of nutrient (kg/ha)				
		N	P	K	Ca	Mg
Grain	1.0	25	6	15	3.0	2.0
Stem & leaves	1.5	15	3	18	4.5	3.0
Total	2.5	40	9	33	7.5	5.0
Grain	4.0	63	12	30	8.0	6.0
Stem & leaves	4.0	37	6	38	10.0	8.0
Total	8.0	100	18	68	18.0	14.0
Grain	7.0	128	20	37	14.0	11.0
Stem & leaves	7.0	72	14	93	17.0	13.0
Total	14.0	200	34	130	31.0	24.0

(Cited from Sanchez, 1976)

Table 2.1.14 Yield of Tomato (Transplanting date: 28th of September)

Item	Red Kaki (no debud.)	Red Kaki (debudding)	Magokoro (debudding)
Harvesting period	Dec. 12 ~ 28	Dec. 5 ~ 28	Nov. 30 ~ Dec. 28
No. of fruits/100 m^2	394	722	1,069
F.W. of one fruit g	71	93	117
F.W. of fruits kg/0.1 ha	285	666	1,252

Between debudding and no-debudding of Red Kaki: $LSD_{0.05}$ = 225 kg/0.1 ha
Between varieties with debudding: No significant difference

Table 2.1.15 Relationship between Planting Date and Yield of Tomato

Item	Planting Date		
	Aug. 29th	Sept. 16th	Sept. 28th
Harvesting period	Nov. 13 ~ Dec. 10	Nov. 26 ~ Dec. 10	Dec. 5 ~ Dec. 10
No. of fruits/100 m^2	1,891	767	248
F.W. of one fruit g	119	146	170
F.W. of fruits kg/0.1 ha	2,253	1,132	420

$LSD_{0.01}$ = 945 kg/0.1 ha, $LSD_{0.05}$ = 575 kg/0.1 ha

Table 2.1.16 Relationship between Seeding Date and Yield of Sweet Corn

Item	Seeding Date		
	Aug. 14th	Sept. 4th	Sept. 25th
Harvesting period	Nov. 3 ~ Nov. 6	Nov. 23 ~ Nov. 26	Dec. 12 ~ Dec. 15
No. of growing days	82 ~ 85	81 ~ 84	79 ~ 82
Length of stem cm	74	85	101
F.W. of one cob g	157	157	213
No. of cob/100 m^2	384	431	426
F.W. of cobs t/ha [1)]	60	67	93

1) No significant difference

2.2 Guideline of Farming System

As agriculture in Zambia depends mostly on rain-fed farming, a single cropping system during the rainy season is dominant. In the dry season, cassava, a tolerated permanent crop under dry weather conditions is possible but most arable land is left fallow except for some areas where cotton and wheat crops are farmed.

However, the target area in this verification study has focused on the edge of the Zambezi floodplain and its outerplain where it is possible to utilize some water sources for farming even in the dry season. The vrification study team proved in the Namushakende verification farm that the introduction of rice combined with cool dry season crops or hot dry season crops during the dry season was technically and economically quite feasible. This double cropping system is believed to play a role for small-scale farmers to utilize arable land effectively, and also to boost the total output, and furthermore to activate the idle labor force during the dry season in this area.

Therefore, focusing on small-scale farmers in the Mongu district, the guidelines of farming systems were drawn based on the following prerequisite conditions.

(1) Management strategy: Diversified farming of paddy rice and upland crop with 5 - 6 heads of cattle raising

(2) Scale of cultivation land/farm-household: 2 - 5 ha

(3) Family workers: 3 - 4 member

(4) Basic working means: Farming by using a hoe except for plowing and harrowing operations done with oxen which is ordered from outside

(5) Cropping system: Single cropping system of paddy rice
Double cropping system of "Rice-Cool dry season crops"
Double cropping system of "Rice-Hot dry season crops"

(6) Field condition: Double cropping system of "rice-upland crop" is suited to the area on the floodplain edge where peat-muck soils dominate (thickness of the said soil is around 20 cm) and the areas with sandy loam soils which are equipped with drainage and irrigation facilities.

Single cropping system of rice is suited to areas associated with insufficient drainage conditions at the beginning and end of the dry season.

The guidelines of farming systems actually drawn are as follows; each guideline indicates a target yield, cropping season, operation sequence, and cultivation system (Farm operation and details) plus a balance sheet of cost and return analyses.

Guideline of Rice single cropping system (2.2.1)

(1)	Early rice single cropping system	(in good field conditions)
(2)	- ditto -	(in poor field conditions) - cultivation system is same as (1).
(3)	Late rice single cropping system	(in good field conditions)
(4)	- ditto -	(in poor field conditions) - cultivation system is same as (3).

Guideline of Double cropping system for "Early rice - Cool Dry Season Crop" (2.2.2)

(1) Early rice - Wheat cropping system
(2) Early rice - Onion cropping system
(3) Early rice - Cabbage cropping system

Guideline of Double cropping system for "Late rice - Hot dry Season Crop" (2.2.3)

(1) Late rice - Maize cropping system
(2) Late rice - Tomato cropping system

The combination of the cropping system and its profitability in Section 2.2.4 refers to the combination model of each cropping system mentioned above and its profitability on a farm-household basis.

2.2.1 Single Cropping of Paddy Rice

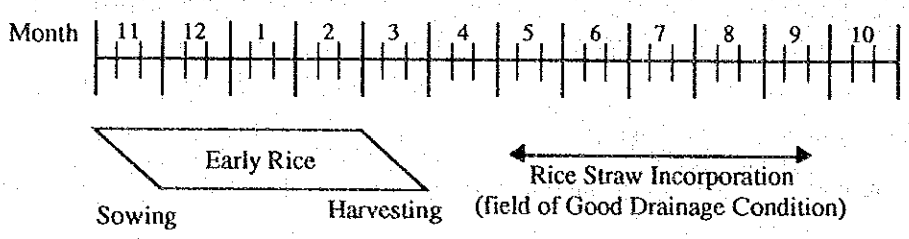
(1) Single cropping system of early maturing rice

Target yield:

6 t/ha; This target yield is based on field conditions where soil fertility can be built by incorporating rice straw into the field during the dry season under good drainage conditions.

4.5 t/ha; This target yield is based on field conditions where it is not possible to use rice straw or in poor drainage conditions associated with low soil fertility.

Cropping pattern:



Operation sequence figure:

[MP] Lime application	[OX] Plowing	[OX] Harrowing	[MP] Levelling	[MP] Making seeding furrow	[MP] Sowing	[MP] Basal dressing
[MP] Water manage-ment	[MP] Top dressing	[MP] Weeding practice	[MP] Bird scaring	[MP] Harvest by sickle at ground level	[MP] Threshing by beating sheaves on plank	[MP] Winnowing by wind selection

Note: [MP] refer to manpower
[OX] refer to oxen

Table 2.2.1 The Guideline of Early Maturing Rice Cultivation in "Early Maturing Rice Single Cropping System ("Good Condition of the Field)

(2) \ (1)	Land Preparation	Sowing	Fertilizer Application	Cultural Management	Harvest Processing
Work criteria	• Scattering rice straw & incorporation • Regular plowing • Lime application • Plowing/Harrowing • Leveling	• Seed selection via water • Sun dry • Making seeding furrow & covering seeds with soil • Seed rate: 60 kg/ha 30 cm row space drill seeding • Variety: C1158, ITA234, Xiang Zhou 5, ITA222, ITA225, Angola crystal	• Basal dressing (Bd): D'mix 250 kg/ha • Topdressing (Td): Urea 100 kg/ha	• Weeding practice • Shifting to flooding • Control of bird damage • Control of rat damage • Control of black maize beetles	• Harvest: 30 days after flowering when 2/3 of rachis tip change to yellow. • Ground level harvesting • Threshing: Beating sheaves to a plank • Winnowing: Wind selection
Working procedure	• Following harvesting rice, scatter the rice straw (RS). • Incorporate RS when field is relatively dry. • Plowing field regularly to accelerate decomposition of RS. • Scattering lime on field, plowing, harrowing and leveling should be done.	• Screening seeds via water and weigh 60 kg of sundried seeds. • Making seeding furrows 30 cm row space by line maker • Seeding per row by a measuring cup made before hand. • Covering seeds with soil by foot from both sides.	• Applying Bd by broadcasting after emergence • Intertilleging in between rows to mix fertilizer with soils	• Shifting to flooding after emergence. • Practicing bird scaring operations and setting rat trap at emergence & ripening stages • Cleaning weeds around paddy field	• Cut rice plant at ground level and heap them by arranging panicles in same direction. • Thresh grains by beating sheaves on a plank placed on a straw mat • Winnow grains by dropping from chest height by using a ball
Optimal time to work	• RS scattering: Late April • RS incorporation: When top soil is relatively dry so as to make oxen plowing • Lime application and plowing/harrowing: Late October	• Mid-November to late-November	• Bd: Early Dec. - mid Dec. • Td: 1) Early Jan. 2) Mid Feb.	• Shifting to flooding: Early Dec - mid Dec.	• Mid March - late March
Farming tools	• 4 head oxen-plow • 4 head oxen-harrow • Rake	• Line maker for 3 seeding furrows		• Hoe	• Serrated sickle
Party of work	• 3 workers				
Consumed time for work/ha	• RS incorporation 100 hrs • Lime application 20 hrs • Plowing: 60 hrs • Harrowing: 60 hrs • Leveling: 100 hrs	• Sowing: 165 hrs	• Bd: 13 hrs • Td: 13 hrs	• Weeding: 377 hrs • Water management: 50 hrs • Bird scaring: 960 hrs	• Harvest: 164 hrs • Winnow: 320 hrs
Materials for input/ha	• Lime: 1,500 kg	• Seeds screened via water: 60 kg	• D'mix: 250 kg • Urea: 100 kg		• Jutebag: 75 bags
Remarks	• Harrowing should be done throughly as to not leave any soil clods more than fist size. • Accelerating decomposition process of RS, plow field regularly (2, 3 times) • No need to lime unless highly acid soil	• Depth of seed cover with soil is around 2 - 3 cm.	• Intertillage is better to be done after applying fertilizer.	• When black maize beetles (Heteronychus spp) appear in the field during upland stage, flood the field at once.	• If thresher and winnower by manpower are available, use them.

Notes: (1) Operation item
(2) Operation details

Table 2.2.2 Cost - Return Analysis for Single Cropping of Early Maturing Rice (Good field condition)

1) Expenditure

(kw/ha)

Direct Cost	Amount of input	Unit price	Expenditure
Fertilizer			
Lime	1500 kg	5.5 kw/kg	8250
D'mix	250	16	4000
Urea	100	16	1600
Sub total			13850
Materials			
Seeds	60 kg	37.5 kw/kg	2250
Jute bag	75 bags	50 kw/bag	3750
Sub total			6000
Labor			
Rice straws scattering	100 hrs	28.6 kw/hr	2860
Rice Straw incorporation	1 ha	(hired oxen)	4800
Plowing	1 ha	(hired oxen)	2400
Harrowing	1 ha	(hired oxen)	1200
Leveling	100 hrs	28.6 kw/hr	2860
Sowing	165 hrs	"	4719
Fertilizing	46 hrs	"	1316
Weeding	377 hrs	"	10782
Water management	50 hrs	"	1430
Bird scaring	960 hrs	9.2 kw/hr	8832
Harvest	164 hrs	28.6 kw/hr	4690
Threshing/Winnow	320 hrs	"	9152
Sub total			55041
Ground total			74891

Note: The Zambian currency unit "kw" is based on May, 1992 value. (US$ = 136 kw)

2) Sale value

Grain yield : 6 t/ha, Sale price : 3000 kw / 80 kg bag

Thus, sale value/ha : 225000 kw

3) Balance/ha

225000 kw - 74891 kw = 150109 kw

Table 2.2.3 Cost - Return Analysis for Single Cropping of Early Maturing Rice (Poor field condition)

1) Expenditure

(kw/ha)

Direct Cost	Amount of input	Unit price	Expenditure
Fertilizer			
Lime	1500 kg	5.5 kw/kg	8250
D'mix	250	16	4000
Urea	100	16	1600
Sub total			13850
Materials			
Seeds	60 kg	37.5 kw/kg	2250
Jute bag	75 bags	50 kw/bag	3000
Sub total			5250
Labor			
Plowing	1.ha	(hired oxen)	4800
Harrowing	1 ha	(hired oxen)	1200
Leveling	100 hrs	28.6 kw/hr	2860
Sowing	165 hrs	"	4719
Fertilizing	46 hrs	"	1316
Weeding	377 hrs	"	10782
Water management	50 hrs	"	1430
Bird scaring	960 hrs	9.2 kw/hr	8832
Harvest	164 hrs	28.6 kw/hr	4690
Threshing/Winnow	240 hrs	"	6864
Sub total			47493
Ground total			66593

Note: The Zambian currency unit "kw" is based on May, 1992 value. (US$ = 136 kw)

2) Sale value

Grain yield : 4.5 t/ha, Sale price : 3000 kw / 80 kg bag

Thus, sale value/ha : 168750 kw

3) Balance/ha

168750 kw - 66593 kw = 102157 kw

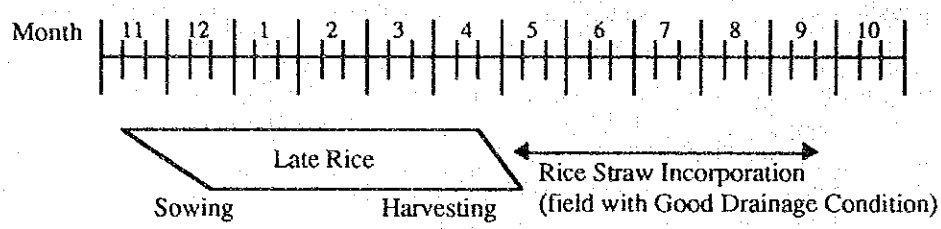
(2) Single cropping system of late maturing rice (Good field conditions)

Target yield:

5.5 t/ha; This target yield is based on field conditions where soil fertility can be built by incorporating rice straws into the field during the dry season under good drainage conditions.

4.5 t/ha; This target yield is based on the field conditions where not possible to use rice straw or in poor drainage conditions

Cropping pattern:



Operation sequence figure:

[MP] Lime application	[OX] Plowing	[OX] Harrowing	[MP] Levelling	[MP] Making seeding furrow	[MP] Sowing	[MP] Basal dressing
[MP] Water manage-ment	[MP] Top dressing	[MP] Weeding practice	[MP] Bird scaring	[MP] Harvest by sickle at ground level	[MP] Threshing by beating sheaves on plank	[MP] Winnowing by wind selection

Note: [MP] refer to manpower
[OX] refer to oxen

Table 2.2.4 The Guideline of Late Maturing Rice Cultivation in "Late Maturing Rice Single Cropping System ("Good Condition of the Field)

(2) \ (1)	Land Preparation	Sowing	Fertilizer Application	Cultural Management	Harvest Processing
Work criteria	• Scattering rice straw & incorporation • Regular plowing • Lime application • Plowing/Harrowing • Leveling	• Seed selection via water • Sun dry • Making seeding furrow & covering seeds with soil • Seed rate: 60 kg/ha 30 cm row space drill seeding • Variety: C1158, ITA234, Xiang Zhou 5, ITA222, ITA225, Angola crystal	• Basal dressing (Bd): D'mix 250 kg/ha • Topdressing (Td): Urea 100 kg/ha	• Weeding practice • Shifting to flooding • Control of bird damage • Control of rat damage • Control of black maize beetles	• Harvest: 30 days after flowering when 2/3 of rachis tip change to yellow. • Ground level harvesting • Threshing: Beating sheaves to a plank • Winnowing: Wind selection
Working procedure	• Following harvesting rice, scatter the rice straw (RS). • Incorporate RS when field is relatively dry. • Plowing field regularly to accelerate decomposition of RS. • Scattering lime on field, plowing, harrowing and leveling should be done.	• Screening seeds via water and weigh 60 kg of sundried seeds. • Making seeding furrows 30 cm row space by line maker • Seeding per row by a measuring cup made before hand. • Covering seeds with soil by foot from both sides.	• Applying Bd by broadcasting after emergence • Intertilleging in between rows to mix fertilizer with soils	• Shifting to flooding after emergence. • Practicing bird scaring operations and setting rat trap at emergence & ripening stages • Cleaning weeds around paddy field	• Cut rice plant at ground level and heap them by arranging panicles in same direction. • Thresh grains by beating sheaves on a plank placed on a straw mat • Winnow grains by dropping from chest height by using a ball
Optimal time to work	• RS scattering: Late May • RS incorporation: When top soil is relatively dry so as to make oxen plowing • Lime application and plowing/harrowing: Late October	• Mid-November to mid - Dec.	• Bd: Early Dec. - late Dec. • Td: 1) Early Jan. 2) Mid Feb.	• Shifting to flooding: Early Dec. - late Dec.	• Mid April
Farming tools	• 4 head oxen-plow • 4 head oxen-harrow • Rake	• Line maker for 3 seeding furrows		• Hoe	• Serrated sickle
Party of work	• 3 workers				
Consumed time for work/ha	• RS incorporation 100 hrs • Lime application 20 hrs • Plowing: 60 hrs • Harrowing: 60 hrs • Leveling: 100 hrs	• Sowing: 165 hrs	• Bd: 13 hrs • Td: 13 hrs	• Weeding: 377 hrs • Water management: 50 hrs • Bird scaring: 960 hrs	• Harvest: 164 hrs • Winnow: 300 hrs
Materials for input/ha	• Lime: 1,500 kg	• Seeds screened via water: 60 kg	• D'mix: 250 kg • Urea: 100 kg		• Jutebag: 75 bags
Remarks	• Harrowing should be done throughly as to not leave any soil clods more than fist size. • Accelerating decomposition process of RS, plow field regularly (2, 3 times) • No need to lime unless highly acid soil	• Depth of seed cover with soil is around 2 - 3 cm.	• Intertillage is better to be done after applying fertilizer.	• When black maize beetles (Heteronychus spp) appear in the field during upland stage, flood the field at once.	

Notes: (1) Operation item
(2) Operation details

Table 2.2.5 Cost - Return Analysis for Single Cropping of Late Maturing Rice (Good field condition)

1) Expenditure

(kw/ha)

Direct Cost	Amount of input	Unit price	Expenditure
Fertilizer			
Lime	1500 kg	5.5 kw/kg	8250
D'mix	250	16	4000
Urea	100	16	1600
Sub total			13850
Materials			
Seeds	60 kg	37.5 kw/kg	2250
Jute bag	70 bags	50 kw/bag	3500
Sub total			5750
Labor			
Rice straws scattering	100 hrs	28.6 kw/hr	2860
Rice Straw incorporation	1 ha	(hired oxen)	4800
Plowing	1 ha	(hired oxen)	2400
Harrowing	1 ha	(hired oxen)	1200
Leveling	100 hrs	28.6 kw/hr	2860
Sowing	165 hrs	"	4719
Fertilizing	46 hrs	"	1316
Weeding	377 hrs	"	10782
Water management	50 hrs	"	1430
Bird scaring	960 hrs	9.2 kw/hr	8832
Harvest	164 hrs	28.6 kw/hr	4690
Threshing/Winnow	300 hrs	"	8580
Sub total			54469
Ground total			74069

Note: The Zambian currency unit "kw" is based on May, 1992 value. (US$ = 136 kw)

2) Sale value

Grain yield : 6 t/ha, Sale price : 3000 kw / 80 kg bag

Thus, sale value/ha : 225000 kw

3) Balance/ha

225000 kw - 74069 kw = 132181 kw

Table 2.2.6 Cost - Return Analysis for Single Cropping of Late Maturing Rice (Poor field condition)

1) Expenditure

(kw/ha)

Direct Cost	Amount of input	Unit price	Expenditure
Fertilizer			
Lime	1500 kg	5.5 kw/kg	8250
D'mix	250	16	4000
Urea	100	16	1600
Sub total			13850
Materials			
Seeds	60 kg	37.5 kw/kg	2250
Jute bag	60 bags	50 kw/bag	3000
Sub total			5250
Labor			
Plowing	1.ha	(hired oxen)	4800
Harrowing	1 ha	(hired oxen)	1200
Leveling	100 hrs	28.6 kw/hr	2860
Sowing	165 hrs	"	4719
Fertilizing	46 hrs	"	1316
Weeding	377 hrs	"	10782
Water management	50 hrs	"	1430
Bird scaring	960 hrs	9.2 kw/hr	8832
Harvest	164 hrs	28.6 kw/hr	4690
Threshing/Winnow	240 hrs	"	6864
Sub total			47493
Ground total			66593

Note: The Zambian currency unit "kw" is based on May, 1992 value. (US$ = 136 kw)

2) Sale value

Grain yield : 4.5 t/ha, Sale price : 3000 kw / 80 kg bag

Thus, sale value/ha : 168750 kw

3) Balance/ha

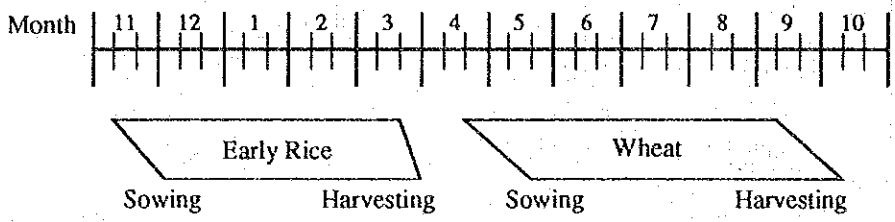
168750 kw - 66593 kw = 102175 kw

2.2.2 Double Cropping System of Early Maturing Rice - Cool Dry Season Crops

(1) Early maturing rice - wheat cropping system

Target yield: Early maturing rice (paddy) ..... 5.0 t/ha
Wheat ..... 2.2 t/ha

Cropping pattern:



Operation sequence figure:

[Rice] (Direct Sowing)

[MP] Lime application	[OX] Plowing	[OX] Harrowing	[MP] Levelling	[MP] Making seeding furrow	[MP] Sowing	[MP] Basal dressing
[MP] Water manage-ment	[MP] Top dressing	[MP] Weeding practice	[MP] Bird scaring	[MP] Harvest by sickle at ground level	[MP] Threshing by beating sheaves on plank	[MP] Winnowing by wind selection

[Wheat]

[OX] Plowing	[OX] Harrowing	[MP] Liming	[MP] Basal dressing	[MP] Levelling	[MP] Making seeding furrow	[MP] Weeding
[MP] Top dressing	[MP] Intertillage	[MP] Harvest by sickle	[MP] Drying sheaves & grains	[MP] Threshing by beating sheaves on plank	[MP] Winnowing by wind selection	[MP] Sacking grains

Note: [MP] refer to manpower
[OX] refer to oxen

Table 2.2.7 The Guideline of Early Maturing Rice Cultivation in "Early Maturing Rice - Wheat Double Cropping System"

(2) \ (1)	Land Preparation	Sowing	Fertilizer Application	Cultural Management	Harvest Processing
Work criteria	• Lime application • Plowing/Harrowing • Leveling	• Seed selection via water • Sun dry • Making seeding furrow & covering seeds with soil • Seed rate: 60 kg/ha 30 cm row space drill seeding • Variety; C1158, ITA234, Xiang Zhou 5, ITA222, ITA225, Angola crystal	• Basal dressing (Bd): D'mix 250 kg/ha • Topdressing (Td): Urea 100 kg/ha	• Weeding practice • Shifting to flooding • Control of bird damage • Control of rat damage • Control of black maize beetles	• Harvest: 30 days after flowering when 2/3 of rachis tip change to yellow. • Ground level harvesting • Threshing: Beating sheaves to a plank • Winnowing: Wind selection
Working procedure	• Scattering lime on field, plowing, harrowing and leveling should be done.	• Screening seeds via water and weigh 60 kg of sundried seeds. • Making seeding furrows 30 cm row space by line maker • Seeding per row by a measuring cup made before hand. • Covering seeds with soil by foot from both sides.	• Applying Bd by broadcasting after emergence • Intertilleging in between rows to mix fertilizer with soils	• Shifting to flooding after emergence. • Practicing bird scaring operations and setting rat trap at emergence & ripening stages • Cleaning weeds around paddy field	• Cut rice plant at ground level and heap them by arranging panicles in same direction. • Thresh grains by beating sheaves on a plank placed on a straw mat • Winnow grains by dropping from chest height by using a ball
Optimal time to work	• Lime application and plowing/harrowing: Late October	• Mid-November	• Bd: Early Dec. • Td: 1) Early Jan. 2) Mid Feb.	• Shifting to flooding: Early Dec.	• Mid March
Farming tools	• 4 head oxen-plow • 4 head oxen-harrow • Rake	• Line maker for 3 seeding furrows		• Hoe • Rake	• Serrated sickle
Party of work	• 3 workers			• Birdscaring: 4 labors	
Consumed time for work/ha	• Lime application 20 hrs • Plowing: 60 hrs • Harrowing: 60 hrs • Leveling: 100 hrs	• Sowing: 165 hrs	• Bd: 13 hrs • Td: 13 hrs	• Weeding: 377 hrs • Water management: 50 hrs • Bird scaring: 960 hrs	• Harvest: 164 hrs • Winnow: 270 hrs
Materials for input/ha	• Lime: 1,500 kg	• Seeds screened via water: 60 kg	• D'mix: 250 kg • Urea: 100 kg		• Jutebag: 65 bags
Remarks	• Harrowing should be done throughly as to not leave any soil clods more than fist size. • No need to lime unless highly acid soil	• Depth of seed cover with soils is around 2 - 3 cm.	• Intertillage is better to be done after applying fertilizer.	• When black maize beetles (Heteronychus spp) appear in the field during upland stage, flood the field at once.	

Notes: (1) Operation item
(2) Operation details

Table 2.2.8 The Guideline of Wheat Cultivation in "Early Maturing Rice - Wheat Double Cropping System"

(2) \ (1)	Land Preparation	Basal Dressing	Making Seeding Furrows	Sowing	Weeding
Work criteria	• Draining water after rice cropping • Plowing by oxen • Harrowing field by oxen after dry • Liming/fertilization • Leveling	• Lime: 1,000 kg/ha • Basal dressing: D'mix (10-20-10) 300 kg/ha • Cupper sulphate: 30 kg/ha	• 25 cm between rows • Seeding depth: 3 cm	• Variety: Jupateco or Loerie II • Seed rate: 100 kg/ha drilling • Covering depth: 2-3 cm beetles	• 2 times
Working procedure	• Promoting drainage of the field after harvesting rice • When field is dryed to support oxen, plow by oxen. • Drying the field approx. 10 days, harrow it by oxen.	• After plowing by oxen roughly, broadcasting lime and fertilizer. • Then harrowing the field at shallow depth to mix surface soils and fertilizer. • Then leveling the field.	• Use a line maker as shown in Figure 2.3.1. • Tighten a string between both side of the field (direction of furrow) • Drawing the line maker along the string by adjusting a maker to the string	• Seeding uniformly along the seeding furrow • Then covering seeds with soils by using both legs carefuly.	• Voluntary rice also come out with weed. Uproot weed and rice carefully not so as to mix wheat and rice.
Optimal time to work	• Mid April to mid May	• Mid April to late May	• Mid April to late May	• Mid April to late May	• Around 10 and 30 days after emergence
Farming tools	• Oxen-plow • Oxen-harrow	• Oxen harrow	• Line maker		
Party of work	• 3 workers (order of outside)		• 2 workers		
Consumed time for work/ha	• Plowing: 20 hrs x 3 man = 60 hrs • Harrowing: 20 hrs x 3 man = 60 hrs (Ordering outside)	• Basal dressing: 50 hrs • Leveling: 40 hrs	• 50 hrs	• 110 hrs	• 240 hrs:
Materials for input/ha		• Lime 1,000 kg, D'mix (10-20-10) 300 kg, Cupper sulphate: 30 kg			
Remarks	• Its better to group the field based on similar water regime. • Avoiding the field of above 30 cm peat-muck soil layer with poor drainage condition	• Cupper sulphate is better to be applied by mixing with soil due to small quantity. • No need to lime unless strong acid soil		• Variety-J 130 and Coucal are adaptable as well. • Pay attention to rat damage after emergence. • Overseeding is recommended in case of poor emerge row	

Notes: (1) Operation item
(2) Operation details

Table 2.2.8 The Guideline of Wheat Cultivation in "Early Maturing Rice - Wheat Double Cropping System" (continued)

(2) \ (1)	Top Dressing	Harvest & Dry	Threshing and Processing
Work criteria	• Urea: 100 kg/ha	• Cut at ground level • Dry them in the field	• Beating wheat bundle on a plank or by stick • Wind selection beating wheat bundle by stick
Working procedure	• Applying urea beside hills evenly • Then stir soils between rows by hoe slightly.	• Harvest when top turn to yellow • Cut stock at 10 cm above ground level by sickle • Arrange ear of wheat bundle in same direction and dry them in the field for 4-5 days	• Collect wheat bundle by arranging panicles in same direction, and carry to a place to thresh • Selecting a flat area in drying condition • Threshing must be done on a sheet. • After winnowing, fill a jute bag with grains.
Optimal time to work	• Around 3 week after emergence	• Early sowing: Early Sept. - mid Sept. • Late sowing: Mid Sept. - early Oct.	• After harvest & drying process: mid Sept-early Oct.
Farming tools	• Hoe	• Serrated sickle	• Plank, stick, sheet
Party of work			• 3 workers
Consumed time for work/ha	• Top dressing: 50 hrs • Intertillage: 100 hrs	• 200 hrs	• 320 hrs
Materials for input/ha	• Urea: 100 kg		
Remarks	• Watering if the soil is dry after topdressing.	• Cut wheat culms without roots. Otherwise, soil is mixing with grains at processing and need time to separate. • Pay attention to rat damage at ripening stage.	• Use thresher and winnower by manual type if available.

Notes: (1) Operation item
(2) Operation details

Table 2.2.9 Cost - Return Analysis for Rice in "Early Rice - Wheat" Cropping System

1) Expenditure

(kw/ha)

Direct Cost	Amount of input	Unit price	Expenditure
Fertilizer			
Lime	1500 kg	5.5 kw/kg	8250
D'mix	250	16	4000
Urea	100	16	1600
Sub total			13850
Materials			
Seeds	60 kg	37.5 kw/kg	2250
Jute bag	65 bags	50 kw/bag	3250
Sub total			5500
Labor			
Plowing	1 ha	(hired oxen)	2400
Harrowing	1 ha	(hired oxen)	1200
Leveling	100 hrs	28.6 kw/hr	2860
Sowing	165 hrs	"	4719
Fertilizing	46 hrs	"	1316
Weeding	377 hrs	"	10782
Water management	50 hrs	"	1430
Bird scaring	960 hrs	9.2 kw/hr	8832
Harvest	164 hrs	28.6 kw/hr	4690
Threshing/Winnow	270 hrs	"	7722
Sub total			45951
Ground total			65301

Note: The Zambian currency unit "kw" is based on May, 1992 value. (US$ = 136 kw)

2) Sale value

Grain yield : 5 t/ha, Sale price : 3000 kw / 80 kg bag

Thus, sale value/ha : 187500 kw

3) Balance/ha

187500 kw - 65301 kw = 122199 kw

Table 2.2.10 Cost - Return Analysis for Wheat in "Early Rice - Wheat" Cropping System

1) Expenditure

(kw/ha)

Direct Cost	Amount of input	Unit price	Expenditure
Fertilizer			
Lime	1500 kg	5.5 kw/kg	5500
D'mix	250	16	4800
Urea	100	16	1600
Copper sulphrste	30	16	480
Sub total			12380
Materials			
Seeds	100 kg	300 kw/kg	3750
Jute bag	25 bags	50 kw/bag	1250
Sub total			5000
Labor			
Plowing	1.ha	(hired oxen)	2400
Harrowing	1 ha	(hired oxen)	2400
Leveling	40 hrs	28.6 kw/hr	1144
Fertilizing	50 hrs	"	1430
Making seeding furrow	50 hrs	"	1430
Sowing	110 hrs	"	3146
Top dressing & mixing with coils	150 hrs	"	4290
Weeding	240 hrs	"	6864
Harvest	200 hrs	"	5720
Threshing/Winnow	240 hrs	"	6864
Sub total	1080 hrs		35688
Ground total			53068

Note: The Zambian currency unit "kw" is based on May, 1992 value. (US$ = 136 kw)

2) Sale value

Grain yield : 2.2 t/ha, Sale Sale price : 3000 kw / 90 kg bag

Thus, sale value/ha : 73333 kw

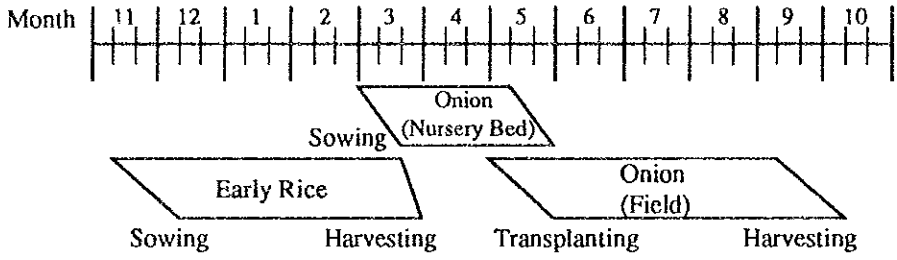
3) Balance/ha

73333 kw - 53608 kw = 20264 kw

(2) Early maturing rice - onion cropping system

Target yield: Early maturing rice (paddy rice) ..... 5.0 t/ha
Onion ..... 20 t/ha

Cropping pattern:



Operation sequence figure:

[Early maturing rice: direct sowing]

	[MP] Lime application	[OX] Plowing	[OX] Harrowing	[MP] Levelling	[MP] Making seeding furrow	[MP] Sowing	[MP] Basal dressing
	[MP] Water manage-ment	[MP] Top dressing	[MP] Weeding practice	[MP] Bird scaring	[MP] Harvest by sickle at ground level	[MP] Threshing by beating sheaves on plank	[MP] Winnowing by wind selection

[Onion]

(Nursery bed)	[MP] Plowing	[MP] Lime application	[MP] Levelling	[MP] Basal dressing	[MP] Mixing with soils	[MP] Sowing
	[MP] Shading bed	[MP] Watering	[MP] Chemical spray	[MP] Thinning	[MP] Removing shading	
(Field)	[OX] Plowing	[OX] Harrowing	[MP] Lime application	[MP] Basal dressing	[MP] Levelling	[MP] Making bed
	[MP] Trans-planting	[MP] Chemical spray	[MP] Top dressing	[MP] Watering	[MP] Weeding	[MP] Harvest

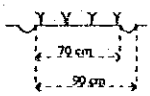
Note: [MP] refer to manpower
[OX] refer to oxen

Table 2.2.11 The Guideline of Early Maturing Rice Cultivation in "Early Maturing Rice - Onion Double Cropping System"

(1) / (2)	Land Preparation	Sowing	Fertilizer Application	Cultural Management	Harvest Processing
Work criteria	• Lime application • Plowing/Harrowing • Leveling	• Seed selection via water • Sun dry • Making seeding furrow & covering seeds with soil • Seed rate: 60 kg/ha 30 cm row space drill seeding • Variety: C1158, ITA234, Xiang Zhou 5, ITA222, ITA225, Angola crystal	• Basal dressing (Bd): D'mix 250 kg/ha • Topdressing (Td): Urea 100 kg/ha	• Weeding practice • Shifting to flooding • Control of bird damage • Control of rat damage • Control of black maize beetles	• Harvest: 30 days after flowering when 2/3 of rachis tip change to yellow. • Ground level harvesting • Threshing: Beating sheaves to a plank • Winnowing: Wind selection
Working procedure	• Scattering lime on field, plowing, harrowing and leveling should be done.	• Screening seeds via water and weigh 60 kg of sundried seeds. • Making seeding furrows 30 cm row space by line maker • Seeding per row by a measuring cup made before hand. • Covering seeds with soil by foot from both sides.	• Applying Bd by broadcasting after emergence • Intertilleging in between rows to mix fertilizer with soils	• Shifting to flooding after emergence. • Practicing bird scaring operations and setting rat trap at emergence & ripening stages • Cleaning weeds around paddy field	• Cut rice plant at ground level and heap them by arranging panicles in same direction. • Thresh grains by beating sheaves on a plank placed on a straw mat • Winnow grains by dropping from chest height by using a ball
Optimal time to work	• Lime application and plowing/harrowing: Late October	• Mid-November ~ late November	• Bd: Early Dec. • Td: 1) Early Jan. 2) Mid Feb.	• Shifting to flooding: Early Dec.	• Mid March ~ late March
Farming tools	• 4 head oxen-plow • 4 head oxen-harrow • Rake	• Line maker for 3 seeding furrows		• Hoe	• Serrated sickle
Party of work	• 3 workers			• Birdscaring: 4 labors	
Consumed time for work/ha	• Lime application 20 hrs • Plowing: 60 hrs • Harrowing: 60 hrs • Leveling: 100 hrs	• Sowing: 165 hrs	• Bd: 13 hrs • Td: 13 hrs	• Weeding: 377 hrs • Water management: 50 hrs • Bird scaring: 960 hrs	• Harvest: 164 hrs • Winnow: 270 hrs
Materials for input/ha	• Lime: 1,500 kg	• Seeds screened via water: 60 kg	• D'mix: 250 kg • Urea: 100 kg		• Jutebag: 65 bags
Remarks	• Harrowing should be done throughly as to not leave any soil clods more than fist size. • No need to lime unless highly acid soil	• Depth of seed cover with soils is around 2 - 3 cm.	• Intertillage is better to be done after applying fertilizer.	• When black maize beetles (Heteronychus spp) appear in the field during upland stage, flood the field at once.	• Use thresher and winnower by man power if available.

Notes: (1) Operation item
(2) Operation details

Table 2.2.12 The Guideline of Onion Cultivation in "Early Maturing Rice - Onion Double Cropping System"

(2) \ (1)	Preparation of Nursery Bed	Sowing	Mansgement of Nursery Bed	Land Preparation	Fertilizer Application (Basal Dressing)	Ridging
Work criteria	• Site selection: Good water regime & virgin land of onion cropping • Area: 50 m^2/ 0.1 ha • Fertilizer: Lime; 5 kg/50 m^2 Cattle manure; 10 kg/50 m^2 D'mix (10-20-10); 2.5 kg/50 m^2	• Row space: 10 cm of drill seeding • Seed rate: 500 g/0.1ha • Variety: Texas early yellow grano	• Watering: every 1-2 days • Shading: from sowing up to 2-3 leaves age: 50-60% cut of sunlight • Thining: at 3 leaves age to thin so as to make 1.5 cm hill space • Plant protection: 1-2 spraying, White leaf spot: (Captan wettable powder 1:500 or Copper wettable powder 1:500)	• Drain the field after rice harvest • Plowing by oxen • Drying the field • Harrowing by oxen • Lime & Fertilizer application • Leveling	• Lime: 100 kg/0.1 ha • Basal dressing: D'mix 50 kg/0.1 ha Dry manure 200 kg/0.1 ha	• Width of ridge 90 cm • Height of bed: 5-6 cm • Width of bed: 70 cm
Working procedure	• Cleaning weeds & leveling of the bed • Making 1 m width flat bed, 50 cm pass road in between nursery beds. • Rasing bed by taking soils from pass road so as to be 5-6 cm height of the bed • Scattering lime, manure & fertilizer on the beds uniformly and leveling beds by mixing them with soils.	• Making seeding furrow with 1 cm depth and 10 cm row space • Sow seeds sparsry • Cover seeds with soils slightly	• Giving water to the bed by watering can to make it well wet. • Shading bed by making roof (grass), 80 cm above beds. • Spraying chemicals on 2-4 weeks after emergence • Thining should be splitted into 2 times and start from poor seedlings.	• Drain the field immediately after rice cropping • Plowing the field when oxen can enter the field • Dry the field 10 days, then harrow by oxen. • Leveling should be done after applying fertilizer (See the column of "basal dressing")	• Scattering lime & basal dressing after harrowing roughly. • Harrowing the field again to mix them with soils, then leveling.	• Making bed of 70 cm width and 6-7 cm high; raising soils into the bed from 20 cm band as illustration. Then, make a bed width 70 cm with 6-7 cm high. 
Optimal working time	• Early to mid March	• Early to end March	• Early March to late-May	• Mid-April to early May	• Late-April to mid-May	• Early to late May
Farming tools	• Hoe • Rake		• Hand sprayer, chemical • Watering can	• Oxen plow • Oxen harrow	• Wheelbarrow	• Hoe • Rake
Party of work	• 2 workers			• 3 workers	• 3 workers	• 2 workers
Consumed time/ 0.1 ha	• 20 hrs	• 4 hrs	• 65 hrs	• Plowing: 6 hrs • Harrowing: 6 hrs (Order outside)	• Liming, manuring fertilization: 5 hrs • Leveling by oxen (order outside) • Supplemental leveling by manpower: 8 hrs	• 24 hrs
Materials/0.1 ha	• Lime: 5 kg/50 m^2 • Cattle manure: 10 kg/50 m^2 • D'mix: 2.5 kg/m^2		• Captan wettable chemical or copper wettable powder 30 gm • Short stick, shading materials		• Lime 100 kg/ 0.1 ha • Cattle manure: 200 kg/0.1 ha • D'mix: 50 kg/0.1ha	• String for making furrows. (same length to furrow)
Remarks		• Do not sow densely and deeply.	• Excess moisture condition of the bed causes disease, thus paying attention not to water beyond optimal condition. • Judging from the growth condition of seedlings, better to apply urea 10 g/m^2 as a topdressing.	• Onion field should be kept away from late rice field. • Pay attention to horizontal percolation from irrigation canal.	• Best soil pH is around 6.0. Liming more if low pH (150 kg/ 0.1 ha)	• In case of the field to get percolated water from adjacent field, reduce a bed size of width and raise bed height up to 10 cm.

Notes: (1) Operation item
(2) Operation details

Table 2.2.12 The Guideline of Onion Cultivation in "Early Maturing Rice - Onion Double Cropping System" (continued)

(1) / (2)	Transplanting	Prevention (field)	Topdressing	Weeding Practice	Harvest & Post Harvest
Work criteria	• 4 rows/bed • Row space: 18 cm • Hill space: 15 cm (29.6 plants/m^2) • Size of seedling to transplant: 5 true leaves, 15 cm plant height	• Target disease: White leaf spot (Phytophthora porri Foister) • Chemical: Captan (wettable powder) 1:500, 60 L/0.1 ha or copper wattable powder	• Urea 10 kg/0.1 ha: one month after transplanting.	• Any time	• Uprooting onion plant and cut dry leaves from the bulbs.
Working procedure	• Provide 2 - 4 strings of every 15 cm marked; length is based on the bed. • Tightening these strings between both edges of bed parallelly 18 cm apart from each string. • Making planting hole of 3-4 cm depth with stick along the mark on the strings. • Giving water to the nursery bed well before uprooting seedlings. • Transplanting them quickly without injuring roots.	• Spray as soon as possible when disease symptom appears. If not, no need to spray.	• Broadcasting urea evenly on the bed • After that, water the bed to dissolve granule fertilizer, or mixing them with soils by stick. • In case of the field being overdryed, better to spray water not so as to exceed optimal water requirement.		• Start harvest when leaves turn into yellow and lodging • Keep the harvest bulbs under shaded and ventilate place.
Optimal working time	• Early to late May	• 2 - 4 weeks after transplanting	• Early to late June	• Early June - mid-September	• Mid September - early October
Farming tools	• Watering can	• Hand sprayer	• Watering can		• Sickle or scissors
Party of work	• 2-3 workers				
Consumed time/ 0.1 ha	• 80 hrs	• 2 hrs	• 16 hrs	• 48 hrs	• 48 hrs
Materials/0.1 ha	• Marked strings (4 strings) for transplanting (same length as furrow)	• Captan wettable powder or copper wettable powder 240 g.	• Urea: 10 kg		• Jute bag: 130 bags (20 kg cap/bag)
Remarks	• Small seedlings are transplanted later.	• Leftover of chemical & rinced water for tools should be disposed in the field not to cannal. • Wash your body after spraying chemical.			

Notes: (1) Operation item
(2) Operation details

Table 2.2.13 Cost - Return Analysis for Rice in "Early Rice - Onion" Cropping System

1) Expenditure

(kw/ha)

Direct Cost	Amount of input	Unit price	Expenditure
Fertilizer			
Lime	1500 kg	5.5 kw/kg	8250
D'mix	250	16	4000
Urea	100	16	1600
Sub total			13850
Materials			
Seeds	60 kg	37.5 kw/kg	2250
Jute bag	65 bags	50 kw/bag	3250
Sub total			5500
Labor			
Plowing	1 ha	(hired oxen)	2400
Harrowing	1 ha	(hired oxen)	1200
Leveling	100 hrs	28.6 kw/hr	2860
Sowing	165 hrs	"	4719
Fertilizing	46 hrs	"	1316
Weeding	377 hrs	"	10782
Water management	50 hrs	"	1430
Bird scaring	960 hrs	9.2 kw/hr	8832
Harvest	164 hrs	28.6 kw/hr	4690
Threshing/Winnow	270 hrs	"	7722
Sub total			45951
Ground total			65301

Note: The Zambian currency unit "kw" is based on May, 1992 value. (US$ = 136 kw)

2) Sale value

Grain yield : 5 t/ha, Sale price : 3000 kw / 80 kg bag

Thus, sale value/ha : 187500 kw

3) Balance/ha

187500 kw - 65301 kw = 122199 kw

Table 2.2.14 Cost - Return Analysis for Onion in "Early Rice - Onion" Cropping System

1) Expenditure

(kw/0.1ha)

Direct Cost	Amount of input	Unit price	Expenditure
Fertilizer			
Lime	105 kg	5.5 kw/kg	578
D'mix	52.5	16	840
Urea	10	16	160
Sub total			1578
Materials			
Chemicals	255 g	640kw/8kg	163
Seeds	200 g	3 kw/kg	600
Net bag	100 bags	30 kw/bag	3000
Sub total			3763
Labor			
Nursery bed (NB) preparation	20 hrs	28.6 kw/hr	572
Sowing (NB)	4 hrs	"	114
Management	65 hrs	"	1859
Plowing (oxen)	0.1 ha	(hired oxen)	240
Harrowing (oxen)	0.1 ha	(hired oxen)	240
Leveling	8 hrs	28.6 kw/hr	229
Fertilizing	5 hrs	"	143
Making beds	24 hrs	"	686
Transplanting	80 hrs	"	2288
Disease & pest control	2 hrs	"	57
Topdressing & intertilleging	16 hrs	"	458
Weeding	48 hrs	"	1373
Harvest	48 hrs	"	1373
Sub total			9632
Ground total			14973

Note: The Zambian currency unit "kw" is based on May, 1992 value. (US$ = 136 kw)

2) Sale value

Grain yield : 2000 kg / 0.1ha, Sale price : 70 kw/kg

Thus, sale value/0.1ha : 140000 kw

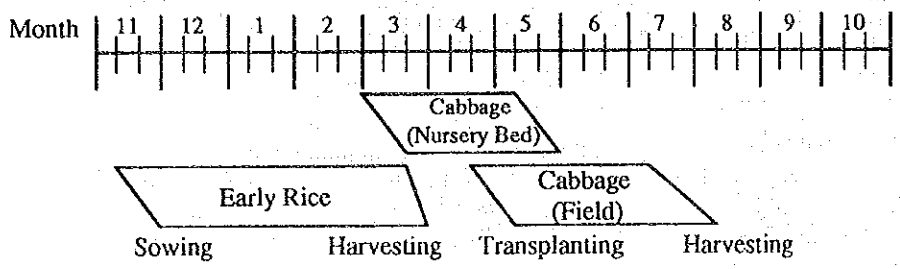
3) Balance/0.1ha

140000 kw - 14973 kw = 125027 kw

(3) Early maturing rice - cabbage cropping system

Target yield: Early maturing rice (paddy rice) ..... 5.0 t/ha
Cabbage ..... 25 t/ha

Cropping pattern:



Operation sequence figure:

[Early maturing rice: direct sowing]

[MP] Lime application	[OX] Plowing	[OX] Harrowing	[MP] Levelling	[MP] Making seeding furrow	[MP] Sowing	[MP] Basal dressing
[MP] Water manage-ment	[MP] Top dressing	[MP] Weeding practice	[MP] Bird scaring	[MP] Harvest by sickle at ground level	[MP] Threshing by beating sheaves on plank	[MP] Winnowing by wind selection

[Cabbage]

(Nursery bed)	[MP] Plowing	[MP] Lime application	[MP] Levelling	[MP] Basal dressing	[MP] Mixing with soils	[MP] Sowing
	[MP] Shading bed	[MP] Watering	[MP] Chemical spray	[MP] Thinning	[MP] Removing shading	
(Field)	[OX] Plowing	[OX] Harrowing	[MP] Lime application	[MP] Basal dressing	[MP] Levelling	[MP] Making bed
	[MP] Trans-planting	[MP] Chemical spray	[MP] Top dressing	[MP] Watering	[MP] Weeding	[MP] Harvest

Note: [MP] refer to manpower
[OX] refer to oxen

Table 2.2.15 The Guideline of Early Rice Cultivation in "Early Maturing Rice - Cabbage Double Cropping System"

(2) \ (1)	Land Preparation	Sowing	Fertilizer Application	Cultural Management	Harvest Processing
Work criteria	• Lime application • Plowing/Harrowing • Leveling	• Seed selection via water • Sun dry • Making seeding furrow & covering seeds with soil • Seed rate: 60 kg/ha 30 cm row space drill seeding • Variety: C1158, ITA234, Xiang Zhou 5, ITA222, ITA225, Angola crystal	• Basal dressing (Bd): D'mix 250 kg/ha • Topdressing (Td): Urea 100 kg/ha	• Weeding practice • Shifting to flooding • Control of bird damage • Control of rat damage • Control of black maize beetles	• Harvest: 30 days after flowering when 2/3 of rachis tip change to yellow. • Ground level harvesting • Threshing: Beating sheaves to a plank • Winnowing: Wind selection
Working procedure	• Scattering lime on field, plowing, harrowing and leveling should be done.	• Screening seeds via water and weigh 60 kg of sundried seeds. • Making seeding furrows 30 cm row space by line maker • Seeding per row by a measuring cup made before hand. • Covering seeds with soil by foot from both sides.	• Applying Bd by broadcasting after emergence • Intertilleging in between rows to mix fertilizer with soils	• Shifting to flooding after emergence. • Practicing bird scaring operations and setting rat trap at emergence & ripening stages • Cleaning weeds around paddy field	• Cut rice plant at ground level and heap them by arranging panicles in same direction. • Thresh grains by beating sheaves on a plank placed on a straw mat • Winnow grains by dropping from chest height by using a ball
Optimal time to work	• Lime application and plowing/harrowing: Late October	• Mid-November ~ late-November	• Bd: Early Dec. • Td: 1) Early Jan. 2) Mid Feb.	• Shifting to flooding: Early Dec.	• Mid March ~ late March
Farming tools	• 4 head oxen-plow • 4 head oxen-harrow • Rake	• Line maker for 3 seeding furrows		• Hoe	• Serrated sickle
Party of work	• 3 workers			• Birdscaring: 4 labors	
Consumed time for work/ha	• Lime application 20 hrs • Plowing: 60 hrs • Harrowing: 60 hrs • Leveling: 100 hrs	• Sowing: 165 hrs	• Bd: 13 hrs • Td: 13 hrs	• Weeding: 377 hrs • Water management: 50 hrs • Bird scaring: 960 hrs	• Harvest: 164 hrs • Winnow: 270 hrs
Materials for input/ha	• Lime: 1,500 kg	• Seeds screened via water: 60 kg	• D'mix: 250 kg • Urea: 100 kg		• Jutebag: 65 bags
Remarks	• Harrowing should be done throughly not so as to not leave any soil clods more than fist size. • No need to lime unless highly acid soil	• Depth of seed cover with soils is around 2 - 3 cm.	• Intertillage is better to be done after applying fertilizer.	• When black maize beetles (Heteronychus spp) appear in the field during upland stage, flood the field at once.	

Notes: (1) Operation item
(2) Operation details

Table 2.2.16 The Guideline of Cabbage Cultivation in "Early Maturing Rice - Cabbage Double Cropping System"

(2) \ (1)	Preparation of Nursery Bed	Sowing on Nursery Bed	Management of Nursery Bed	Field Preparation	Making Planting Hole	Fertilizer (Basal Dressing)
Work criteria	• Field selection: Water is available and no cropping history of cabbage before • Type of nursery bed: Flat bed with 1.0 m wide and 5-6 cm high • Area: 30 m^2 for 0.1 ha field • Amending soil acidity: Lime 150 gm/m^2 • Fertilizer: Dry manure 200 g/m^2, D'mix 50 g/m^2	• Seed rate: 50 g/ 0.1 ha • Row space: 10 cm drilling • Variety: C.H. Market	• Watering: once/1-2 days • Shading: 40 days from sowing • Thining: At 2-3 true leaves to make hill space 4-5 cm • Pest control: 3 times spray, major pest; Hellula Undalis Fabricius Aphididae • PAP emulsion: 1:1000 or Dipterex 1:1000	• Draining of the field after rice • Plowing field by oxen • Drying the field • Harrowing by oxen • Liming • Leveling	• Planting hole: Width of ridge = 0.6 m Hill space = 0.45 m	• Lime: 150 kg/0.1 ha • Cattle manure: 150 kg/0.1 ha • D'mix (10-20-10): 50 kg/0.1 ha
Working procedure	• Cleaning a site for bed & leveling • Demarcate a lot by 1.0 m wide (length is free) and pass of 0.5 m width • Raise the soils from the pass to bed up to 5-6 cm so as to be trapezoide bed. • Broadcast lime, dry manure and D'mix uniformly on the bed and level bed followed by mixing them with soils.	• Make seeding furrow with 1 cm depth and 10 cm row space. Then sow seeds on this furrow sparsely. • Cover seeds with soil so as to hide seeds slightly.	• Watering: Once on every 1 to 2 days by watering can to make bed wet. • Shading: Making roof on the bed with 80 cm high by using grass for roofing materials. • Thinning: Thin the seedlings which are damaged by pest or poor growth at first. • Chemical spray: Every week after emergence.	• After harvesting rice, accelerate draining of the field and plowing by oxen when soil bearing capacity is enough. • Dry field for 10 days and plow by oxen. • Leveling should be done after liming.	• Planting hole (Diam. 25 cm, Depth 6-7 cm) should be made based on the above density.	• Liming before leveling. • Cattle manure and D'mix should be applied to each planting hole. • Put a little soil in a hole to avoid roots of seedlings to touch fertilizer directly.
Optimal time to work	• Early-mid March	• Early to late March	• Early March-late May	• Mid - April ~ early May	• Late April to mid May	• Late April to mid May
Farming tools	• Hoe • Rake		• Watering can • Manual sprayer	• Oxen plow • Oxen harrow	• Hoe	• Wheelbarrow • Hoe
Party of work				• 3 workers	• 2 workers	
Consumed work time/0.1ha	• 16 hrs	• 4 hrs	• 60 hrs	• Plowing: 6 hrs • Harrowing: 6 hrs (Ordering outside)	• 20 hrs	• 12 hrs
Materials for input/0.1ha	• Lime: 4.5 kg/30 m^2 • Dry manure 6 kg/30 m^2 • D'mix 1.5 kg/30 m^2	• Seeds: 50 gm	• Shading materials • Short sticks • PAP emulsion or Dipterex 100 gm		• Strings (equal to a length of furrow)	• Lime: 150 kg • Cattle manure: 150 kg • D'mix: 50 kg
Remarks		• Pay attention not to sow densly or deeply.	• Avoid over watering • Chemical residual and rinsed water of tools should be disposed in the field.	• The field more than 30 cm depth of muck soil is very acidic & poor drainage condition, where is not suitable for cabbage.		• Fertile soil with above pH 5.5 is appropriate.

Notes: (1) Operation item
(2) Operation details

Table 2.2.16 The Guideline of Cabbage Cultivation in "Early Maturing Rice - Cabbage Double Cropping System" (continued)

(2) \ (1)	Final Transplantation	Plant Protection	Topdressing, Intertillage Watering	Weeding	Harvest
Work criteria	• Time to transplant: About 1.5 months of 7-8 true leaves after sowing • Plant density: Row space = 0.6 m Hill space = 0.45 m	• Chemical spray for pest: 2 times after transplanting • Target pest: See the column of "Nursery Management" • Chemicals: PAP emulsion 1:1000 or Dipterex emulsion 1:1000	• Urea: 10 kg + 10 kg for 0.1 ha • Time to apply: 2nd and 6th weeks after transplanting.	• Any time	• Cut stem just below a head.
Working procedure	• Water the nursery bed sufficiently in the morning of transplanting day. • Uprooting seedlings should be done carefully to avoid transplanting injury by pulling seedlings with soils. • Carrying uprooted seedlings to the field, transplant them to each hole with heaped soils. • Water throughly after planting.	• Water for dilution is better to use tap water or to skim a top of river water. • Residual chemical or rinced water for tools must be disposed to the field not cannal. • Rinse hands and foot with soap thoroughly.	• Apply urea near hill in between rows, then intertill. • In case of the field being dryed, water sometimes aside from topdressing.	• Judging the weed infestation in the field, do weeding practice.	• Time to harvest: After forming head and, outer leaf of the head start bending. • Harvest the heads which are ready to pick gradually.
Optimal time to work	• Late April to mid May	• 1st spray: 10 days after transplanting 2nd spray: 20 days after transplanting	• 1st: 3rd week after transplanting • 2nd: 6th week after transplanting	• Any time	• Mid-July to early August
Farming tools	• Wheelbarrow • Watering can	• Hand sprayer	• Watering can • Hoe		• Wheelbarrow • Knife
Party of work	• 2-3 workers				• 2-3 workers
Consumed work time/0.1ha	• 40 hrs	• 8 hrs	• 32 hrs	• 32 hrs	• 48 hrs
Materials for input/0.1ha		• PAP emulsion (50%) or Dipterex emulsion 230 gm	• Urea 20 kg		
Remarks	• Retransplant seedlings of self-topping damaged by insect at early stage. • Small seedling is better to be delayed for transplanting.	• The pests to damage apex of cabbage is a key point to control.	• If the field is watered followed by excess desiccation weather, cracking of head may happen. So avoid excess *dryness condition.*		• Collect the harvested heads to the place under good ventilation. • Sell them as soon as possible.

Notes: (1) Operation item
(2) Operation details

Table 2.2.17 Cost - Return Analysis for Rice in "Early Rice - Cabbage" Cropping System

1) Expenditure

(kw/ha)

Direct Cost	Amount of input	Unit price	Expenditure
Fertilizer			
Lime	1500 kg	5.5 kw/kg	8250
D'mix	250	16	4000
Urea	100	16	1600
Sub total			13850
Materials			
Seeds	60 kg	37.5 kw/kg	2250
Jute bag	65 bags	50 kw/bag	3250
Sub total			5500
Labor			
Plowing	1 ha	(hired oxen)	2400
Harrowing	1 ha	(hired oxen)	1200
Leveling	100 hrs	28.6 kw/hr	2860
Sowing	165 hrs	"	4719
Fertilizing	46 hrs	"	1316
Weeding	377 hrs	"	10782
Water management	50 hrs	"	1430
Bird scaring	960 hrs	9.2 kw/hr	8832
Harvest	164 hrs	28.6 kw/hr	4690
Threshing Winnow	270 hrs	"	7722
Sub total			45951
Ground total			65301

Note: The Zambian currency unit "kw" is based on May, 1992 value. (US$ = 136 kw)

2) Sale value

Grain yield : 5 t/ha, Sale price : 3000 kw / 80 kg bag

Thus, sale value/ha : 187500 kw

3) Balance/ha

187500 kw - 65301 kw = 122199 kw

Table 2.2.18 Cost - Return Analysis for Cabbage in "Early Rice - Cabbage" Cropping System

1) Expenditure

(kw/0.1ha)

Direct Cost	Amount of input	Unit price	Expenditure
Fertilizer			
Lime	154.5 kg	5.5 kw/kg	850
D'mix	51.5	16	824
Urea	20	16	320
Sub total			1994
Materials			
Chemicals	330 g	640 kw/kg	211
Seeds	50 g	5 kw/kg	250
Sub total			461
Labor			
Nursery bed (NB) preparation	16 hrs	28.6 kw/hr	458
Sowing (NB)	4 hrs	"	114
Management	60 hrs	"	1716
Plowing	0.1 ha	(hired oxen)	240
Harrowing	0.1 ha	(hired oxen)	240
Digging planting hole	20 hrs	28.6 kw/hr	572
Fertilizing	12 hrs	"	343
Transplanting	40 hrs	"	1144
Disease & pest control	8 hrs	"	229
Topdressing & intertilleging	32 hrs	"	915
Weeding	32 hrs	"	915
Harvest	48 hrs	"	1373
Sub total			8259
Ground total			10714

Note: The Zambian currency unit "kw" is based on May, 1992 value. (US$ = 136 kw)

2) Sale value

Grain yield : 250 kg/0.1ha, Sale Sale price : 60 kw/kg

Thus, sale value/0.1ha : 150000 kw

3) Balance/0.1ha

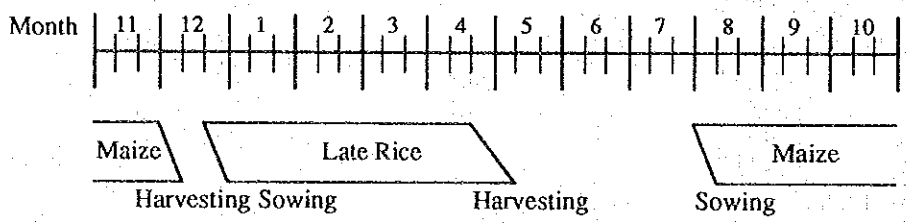
150000 kw - 10714 kw = 139286 kw

2.2.3 Double Cropping system of Late Maturing Rice - Hot Dry Season Crops

(1) Late maturing rice - maize cropping system

Target yield: Rice (paddy) ..... 5 t/ha
Maize ..... 4 t/ha

Cropping pattern:



Operation sequence figure:

[Rice]

[MP] Lime application - [OX] Plowing - [OX] Harrowing - [MP] Levelling - [MP] Making seeding furrow - [MP] Basal dressing - [MP] Seeding -

[MP] Water manage-ment - [MP] Top dressing - [MP] Weeding practice - [MP] Bird scaring - [MP] Harvest - [MP] Threshing & winnowing

[Maize]

[OX] Plowing - [MP] Lime application - [OX] Harrowing - [MP] Levelling & ridging - [MP] Basal dressing - [MP] Seeding - [MP] Weeding practice -

[MP] Top dressing - [MP] Spraying - [MP] Harvest - [SD] Drying - [MP] Shelling

Note: [MP] refer to manpower
[OX] refer to oxen
[SD] Solar drying

Table 2.2.19 The Guideline of Late Maturing Rice Cultivation in "Late Maturing Rice - Maize Double Cropping System"

(1) / (2)	Land Preparation	Sowing	Fertilizer Application	Cultural Management	Harvest Processing
Work criteria	• Lime application • Plowing/Harrowing • Leveling	• Seed selection via water • Sun dry • Making seeding furrow & covering seeds with soil • Seed rate: 60 kg/ha 30 cm row space drill seeding • Variety: IR8192, P1369, P2023, Angola crystal	• Basal dressing (Bd): D'mix 250 kg/ha • Topdressing (Td): Urea 100 kg/ha	• Weeding practice • Shifting to flooding • Control of bird damage • Control of rat damage • Control of black maize beetles	• Harvest: 30 days after flowering when 2/3 of rachis tip change to yellow. • Ground level harvesting • Threshing: Beating sheaves to a plank • Winnowing: Wind selection
Working procedure	• Scattering lime on field, plowing, harrowing and leveling should be done.	• Screening seeds via water and weigh 60 kg of sundried seeds. • Making seeding furrows 30 cm row space by line maker • Seeding per row by a measuring cup made before hand. • Covering seeds with soils by foot from both sides.	• Applying Bd by broadcasting after emergence • Intertilleging in between rows to mix fertilizer with soils	• Shifting to flooding after emergence. • Practicing bird scaring operations and setting rat trap at emergence & ripening stages • Cleaning weeds around paddy field	• Cut rice plant at ground level and heap them by arranging panicles in same direction. • Thresh grains by beating sheaves on a plank placed on a straw mat • Winnow grains by dropping from chest height by using a ball
Optimal time to work	• Lime application and plowing/harrowing: Mid-late Dec.	• Late-Dec.	• Bd: Early Jan. • Td: 1) Late-Jan. 2) Early-March	• Shifting to flooding: Mid-Jan.	• Late-April to early May
Farming tools	• 4 head oxen-plow • 4 head oxen-harrow • Rake	• Line maker for 3 seeding furrows		• Hoe	• Serrated sickle
Party of work	• 3 workers (Outside order)			• Birdscaring: 4 labors	
Consumed time for work/ha	• Lime application 20 hrs • Plowing: 60 hrs • Harrowing: 60 hrs • Leveling: 100 hrs	• Sowing: 165 hrs	• Bd: 13 hrs • Td: 13 hrs	• Weeding: 370 hrs • Water management: 50 hrs • Bird scaring: 960 hrs	• Harvest: 164 hrs • Winnow: 270 hrs
Materials for input/ha	• Lime: 1,500 kg	• Seeds screened via water: 60 kg	• D'mix: 250 kg • Urea: 100 kg		• Jutebag: 65 bags
Remarks	• Harrowing should be done throughly as to not leave any soil clods more than fist size. • No need to lime unless highly acid soil	• Depth of seed cover with soils is around 2 - 3 cm.	• Intertillage is better to be done after applying fertilizer.	• When black maize beetles (Heteronychus spp) appear in the field during upland stage, flood the field at once.	

Notes: (1) Operation item
(2) Operation details

Table 2.2.20 Guideline of Maize Cultivation in "Late Maturing Rice - Maize Cropping System"

Farm Operation	Land Preparation	Sowing	Fertilizer Application	Cultural Management	Harvest Processing
Work criteria	• Plowing • Broadcasting of Lime • Harrowing • Ridging	• Plant spacing 80cm x 25cm • Seeding method Hill seeding 3 seeds/hill • Seed rate 40kg/ha • Varieties MM502 or MM504	• Basal application D' mix(10-20-10) 300kg/ha • Top dressing Urea 160kg/ha • Potassium chloride 80kg/ha	• Weeding • Pest control for Busseola fusca Sumicidin 20%EM 30ml/water 10 liter twice spraying • Suplementary irrigation	• Manual harvest • Solar drying • Shelling by hand • Cleaning residues
Working procedure	• Plow early when soil is dry to enable of oxe from walking. After spreading lime harrow & leveling. • Make a high ridge of 10-15cm when soil is too wet.	• Make small hole by stick with interval of 25cm, Put 3 seeds in hole and cover it with soil.	• Basal : Apply fert. in shallow ditch of 80 cm interval; soil covering and ridging. • Top dress.: Apply 55-60 days after seeding. Soil covering and earthing.	• Weeding : Twice ; late Sept. & early Nov. • Spraying : 2 weeks & 4 weeks after germination, on leaf surface. • Irrigation : In Sept. if drought.	• Harvest-pile-shell-transport-drying. • Clean, transport & pile residues (for manure).
Optimal time to work	• Plow. : Mid-July • Others : Early Aug.	• Early Aug.	• Basal : Early Aug. • Top : Early Oct.		• Early Dec.
Farming tools	• 4 oxen driven plow and 4 oxen driven harrow			• Weeding : Hoe • Control : Knapsack hand sprayer	• Knife or Handy sheller
Party of work	• 3persons / Plow. • 3persons /Harrow. • Outside order				
Consumed time for work/ha	• Plow.:20h ×3p=60h • Harrow.:20h × 3=60h • Ridging : 100h • Lime spreading :20h	• 70hrs	• Basal : 70hrs • Top : 30hrs	• Weeding : 280hrs • Spraying : 20hrs • Irrigation : 70hrs	• Hravest : 100hrs • Shell. : 140hrs • Clean. : 40hrs
Materials for input/ha	• Lime : 1000kg	• Seed : 40kg	• D' mix : 300kg • Urea : 160kg • Potass. Chlo. : 80kg	• Sumicidin 20%EM: 3000 cc	• Jute bag : 50 bags
Remarks	• Apply 2-3 tons of lime in highly acidic soil such as Namushakende farm • No need to lime unless acied soil	• When seeding is impossible until mid-Aug. due to wet conditions, MMV400 is recommendable	• Zn deficiency often in peat-muck soil such as Namushakende farm. Appli. of $ZnSO_4$ 20 kg/ha is effective	• Need of irrigation facilities for drought in Sept. • Need of Drainage facilities for flooding in late Nov.	

Table 2.2.21 Cost - Return Analysis for Rice in "Late Rice-Maize" Cropping System

1) Expenditure

(kw/ha)

Direct Cost	Amount of input	Unit price	Expenditure
Fertilizer			
Lime	1500 kg	5.5 kw/kg	8250
D'mix	250	16	4000
Urea	100	16	1600
Sub total			13850
Materials			
Seeds	60 kg	37.5 kw/kg	2250
Jute bag	65 bags	50 kw/bag	3250
Sub total			5500
Labor			
Plowing	1 ha	(hired oxen)	2400
Harrowing	1 ha	(hired oxen)	1200
Leveling	100 hrs	28.6 kw/hr	2860
Seeding	165 hrs	"	4719
fertilizing	46 hrs	"	1316
Weeding	370 hrs	"	10582
Water management	50 hrs	"	1430
Bird scaring	960 hrs	9.2 kw/hr	8832
Harvest	164 hrs	28.6 kw/hr	4690
Threshing/Winnow	270 hrs	"	7722
Sub total			45751
Ground total			65101

Note: The Zambian currency unit "kw" is based on May, 1992 value. (US$ = 136 kw)

2) Sale value

Grain yield : 5 t/ha, Sale Sale price : 3000 kw / 80 kg bag

Thus, sale value/ha : 187500 kw

3) Balance/ha

187500 kw - 65101 kw = 122399 kw

Table 2.2.22 Cost - Return Analysis for Maize in "Late Rice-Maize" Cropping System

1) Expenditure

(kw/ha)

Direct Cost	Amount of input	Unit price	Expenditure
Fertilizer			
Lime	1000 kg	5.5 kw/kg	5500
D'mix	300	16	4800
Urea	160	16	2560
Potassium chloride	80 kg	16	1280
Sub total			14140
Materials			
Seeds	40 kg	65 kw/kg	2600
Insecticide	3000 cc	2000 kw/1000cc	6000
Jute bag	45 bags	50 kw/bag	2250
Sub total			10850
Labor			
Plowing	1 ha	(hired oxen)	2400
Harrowing	1 ha	(hired oxen)	1200
Broadcasting of lime	20 hrs	28.6 kw/ha	572
Leveling/Ridging	100 hrs	"	2860
Seeding	70 hrs	"	2002
Fertilizing	100 hrs	"	2860
Weeding	280 hrs	"	8008
Spraying	20 hrs	"	572
Supplementary irrigation	70 hrs	"	2002
Harvest	100 hrs	"	2860
Drying/Shelling	140 hrs	"	4004
Cleaning residues	40 hrs	"	1144
Sub total			30484
Ground total			55474

Note: The Zambian currency unit "kw" is based on May, 1992 value. (US$ = 136 kw)

2) Sale value

Grain yield : 4 t/ha, Sale price : 2000 kw / 90 kg bag

Thus, sale value/ha : 88889 kw

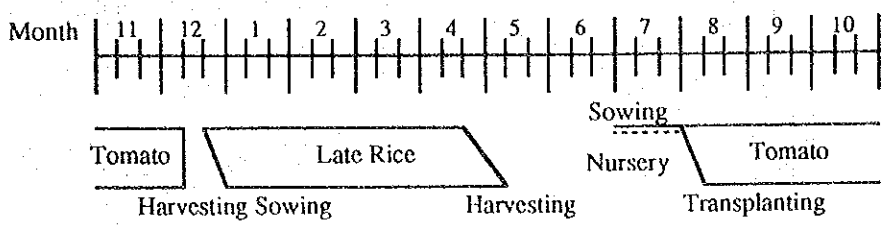
3) Balance/ha

88889 kw - 55474 kw = 33415 kw

(2) Late maturing rice - tomato cropping system

Target yield: Rice (paddy) ..... 5 t/ha
Tomato ..... 30 t/ha

Cropping pattern:



Operation sequence figure:

[Rice]

[MP] Lime application	[OX] Plowing	[OX] Harrowing	[MP] Levelling	[MP] Making seeding furrow	[MP] Basal dressing	[MP] Seeding
[MP] Water manage-ment	[MP] Top dressing	[MP] Weeding practice	[MP] Bird scaring	[MP] Harvest	[MP] Threshing & winnowing	

[Tomato]

(Nursery)	[MP] Plowing	[MP] Levelling	[MP] Basal dressing	[MP] Seeding	[MP] Canopying	[MP] Watering
	[MP] Thinning					
(Field)	[OX] Plowing	[MP] Lime application	[OX] Harrowing	[MP] Levelling & ridging	[MP] Basal dressing	[MP] Trans-planting
	[MP] Supporting	[MP] Watering	[MP] Disbud-ding	[MP] Weeding	[MP] Top dressing	[HS] Spraying
	[MP] Harvest					

Note: [MP] refer to manpower
[OX] refer to oxen
[HS] Hand sprayer

Table 2.2.23 The Guideline of Late Maturing Rice Cultivation in "Late Maturing Rice - Tomato Double Cropping System"

(2) \ (1)	Land Preparation	Sowing	Fertilizer Application	Cultural Management	Harvest Processing
Work criteria	• Lime application • Plowing/Harrowing • Leveling	• Seed selection via water • Sun dry • Making seeding furrow & covering seeds with soil • Seed rate: 60 kg/ha 30 cm row space drill seeding • Variety: IR8192, P1369, P2023, Angola crystal	• Basal dressing (Bd): D'mix 250 kg/ha • Topdressing (Td): Urea 100 kg/ha	• Weeding practice • Shifting to flooding • Control of bird damage • Control of rat damage • Control of black maize beetles	• Harvest: 30 days after flowering when 2/3 of rachis tip change to yellow. • Ground level harvesting • Threshing: Beating sheaves to a plank • Winnowing: Wind selection
Working procedure	• Scattering lime on field, plowing, harrowing and leveling should be done.	• Screening seeds via water and weigh 60 kg after sundried seeds. • Making seeding furrows 30 cm row space by line maker • Seeding per row by a measuring cup made before hand. • Covering seeds with soils by foot from both sides.	• Applying Bd by broadcasting after emergence • Intertilleging in between rows to mix fertilizer with soils	• Shifting to flooding after emergence. • Practicing bird scaring operations and setting rat trap at emergence & ripening stages • Cleaning weeds around paddy field	• Cut rice plant at ground level and heap them by arranging panicles in same direction. • Thresh grains by beating sheaves on a plank placed on a straw mat • Winnow grains by dropping from chest height by using a ball
Optimal time to work	• Lime application and plowing/harrowing: Mid-late Dec.	• Late-Dec.	• Bd: Early Jan. • Td: 1) Late-Jan. 2) End-Feb. to early-Marcy	• Shifting to flooding: Mid-Jan.	• Late-April to early May
Farming tools	• 4 head oxen-plow • 4 head oxen-harrow • Rake	• Line maker for 3 seeding furrows		• Hoe	• Serrated sickle
Party of work	• 3 workers (Outside order)			• Birdscaring: 4 labors	
Consumed time for work/ha	• Lime application 20 hrs • Plowing: 60 hrs • Harrowing: 60 hrs • Leveling: 100 hrs	• Sowing: 165 hrs	• Bd: 13 hrs • Td: 13 hrs	• Weeding: 370 hrs • Water management: 50 hrs • Bird scaring: 960 hrs	• Harvest: 164 hrs • Winnow: 270 hrs
Materials for input/ha	• Lime: 1,500 kg	• Seeds screened via water: 60 kg	• D'mix: 250 kg • Urea: 100 kg		• Jutebag: 65 bags
Remarks	• Harrowing should be done throughly not so as to not leave any soil clods more than fist size. • No need to lime unless highly acid soil	• Depth of seed cover with soil is around 2 - 3 cm.	• Intertillage is better to be done after applying fertilizer.	• When black maize beetles (Heteronychus spp) appear in the field during upland stage, flood the field at once.	

Notes: (1) Operation item
(2) Operation details

Table 2.2.24 Guideline of Tomato Cultivation in "Late Maturing Rice - Tomato Cropping System"

Farm Operation	Nursery Preparation	Seeding	Nursery Management	Field Preparation
Work criteria	• Area $25m^2$ for field of 0.1ha • Fertilizer D' mix (10-20-10) 100 gm/m^2	• Plant spacing 10cm × 1~2cm • Seed rate $20g/25m^2$ • Varieties Red Kaki	• Watering 2 times/day (morning & evening) • Thinning Make plant distance of 5 cm when leaf ages 2~3	• Plowing • Broadcasting of Lime • Harrowing • Ridging
Working procedure	• Width of bed: 100cm • Height of bed: 5cm • Till after bed soil and fertilizer application. • Seeding in early July requires vinyl tunnel for low temperature protection.	• Make small ditch of 5mm depth, interval of 15cm; space/seed in ditch is 1~2cm. • Husk cover on thin soil cover. • Sufficient watering	• Thinning: remove preferentially poor & damaged seedings.	• Plow early when soil is dry to enable oxe from walking. • After lime speading conduct harrowing and leveling. • Hight of ridge: 10~15cm.
Optimal time to work	• Early to mid-July	• Early to mid-July		• Early Aug.
Farming tools				• 4 oxen driven plow and 4 oxen driven harrow
Party of work	• 3persons / Plow. • 3persons /Harrow. • Outside order			• 3persons / Plow. • 3persons /Harrow. • Outside order
Consumed time for work/0.1 ha	• 25 hrs	• 5 hrs	• 75 hrs	• Plowing: 2h ×3p=6 hrs • Harrowing: 2h × 3=6 hrs • Ridging : 16 hrs • Broadcasting Lime:2 hrs
Materials for input/0.1ha	• D' mix 2.5 kg	• Seed : 20kg		• Lime : 100kg
Remarks	• Shift nursery bed annually to avoid failure in replanting. • Prepare bed soil 6 months earlier with straw & fertilizer.	• Sow carefully to avoid dense planing becaouse thinning and weeding would require lots of work.		pH 5.5~6.8 is optimum

Table 2.2.24 Guideline of Tomato Cultivation in "Late Maturing Rice - Tomato Cropping System" (continued)

Farm Operation	Transplanting	Fertilizer Appli.	Growth Management	Harvest
Work criteria	• Plant spacing 70cm × 50cm • 2857 plants/0.1 ha	• Basal application D' mix 50 kg/0.1 ha • Top dressing kg/0.1 ha Urea Potas.Chl 1st 10 8 2nd 10 8 3ed 10 8	• Weeding • Supporting & binding • Control Red spidermite(Tetranchus spp) by spraying acaricide • Control of rat • Supplementaly watering	• Harvest by hand
Working procedure	• Sufficient watering before pulling seedling, to avoid damage. • Dig up seedling with shovel to attach much soil to root. • Plant on the center of ridge.	• Basal: apply in small ditch on ridge, lightly cover soil, planting, completely cover soil. • Top: 30th, 60th, 100th day after planting. • Conduct earthing after dressing.	• Red spidermite occur in season of dry and high temp. (mainly middle to late Oct.) • Watering require during Aug. ~ Oct. • Weeding: must be done timely. • Rat trap.	• Harvest daily by hand in accordance to the degree of maturity demanded in the market.
Optimal time to work	• Early to mid-Aug.	• Basal: early~mid.Aug. • Top: above mentioned	• Supporting & binding Middle~late Aug.	• Late October ~ early December
Farming tools			• Control: Knapsack hand sprayer, Rat trap Weeding: Hoe	
Party of work				
Consumed time for work/0.1 ha	• 36 hrs	• Basal application 10 hrs • Top dressing 21 hrs(7h ×3)	• Weed. 40 h, Spray 4 hrs, • Supporting 120 hrs, • Binding 80 hrs, • Disbud. 80 hrs, Water.70 hrs	• Harvest 260 hrs • Cleaning residues 40 hrs
Materials for input/0.1 ha	• Lime : 1 ton	• D' mix 50 kg • Urea 30 kg • Potass. Chloride 24kg	• Acaricide 10 % EM 300 cc • Support 2858 pieces	
Remarks	• Transplant before 9 AM or after 4 PM. Selected good sedding. • Plant promtly after pulling seedling.		• Armyworm occasionally attacks fruits. Sumition effective for young armyworm. • Diseases seldom occur. • No spraying required.	• Flooding often occurs after late Nov. Need of drainage facilities. • Forward promptly after harvest • Rapid cleaning residues.

Table 2.2.25 Cost - Return Analysis for Rice in "Late Rice-Tomato" Cropping System

1) Expenditure

(kw/ha)

Direct Cost	Amount of input	Unit price	Expenditure
Fertilizer			
Lime	1500 kg	5.5 kw/kg	8250
D'mix	250	16	4000
Urea	100	16	1600
Sub total			13850
Materials			
Seeds	60 kg	37.5 kw/kg	2250
Jute bag	65 bags	50 kw/bag	3250
Sub total			5500
Labor			
Plowing	1 ha	(hired oxen)	2400
Harrowing	1 ha	(hired oxen)	1200
Leveling	100 hrs	28.6 kw/hr	2860
Seeding	165 hrs	"	4719
Fertilizing	46 hrs	"	1316
Weeding	370 hrs	"	10582
Water management	50 hrs	"	1430
Bird scaring	960 hrs	9.2 kw/hr	8832
Harvest	164 hrs	28.6 kw/hr	4690
Threshing/Winnow	270 hrs	"	7722
Sub total			45751
Ground total			65101

Note: The Zambian currency unit "kw" is based on May, 1992 value. (US$ = 136 kw)

2) Sale value

Grain yield : 5 t/ha, Sale price : 3000 kw / 80 kg bag

Thus, sale value/ha : 187500 kw

3) Balance/ha

187500 kw - 65101 kw = 122399 kw

Table 2.2.26 Cost - Return Analysis for Tomato in "Late Rice-Tomato" Cropping System

1) Expenditure

(kw/0.1ha)

Direct Cost	Amount of input	Unit price	Expenditure
Fertilizer			
Lime	100 kg	5.5 kw/kg	550
D'mix	53	16	848
Urea	30	16	480
Potassium chloride	24	16	384
Sub total			2262
Materials			
Seed	20 g	25 kw/g	500
Insecticide	300 cc	200 kw/100cc	600
Supporting materials	2858	20 kw	57160
Sub total			58260
Labor			
Nursery preparation	25 hrs	28.6 kw/ha	715
Seeding	5 hrs	"	143
Nursery management	75 hrs	"	2145
Plowing	0.1 ha	(hired oxen)	240
Harrowing	0.1 ha	(hired oxen)	120
Broadcasting of lime	2 hrs	28.6 kw/ha	57
Leveling/Ridging	16 hrs	"	458
Transplanting	36 hrs	"	1030
Supporting/binding	200 hrs	"	5720
Disbudding	80 hrs	"	2288
Supplementary watering	70 hrs	"	2002
Fertilizing	31 hrs	"	887
Weeding	40 hrs	"	1144
Spraying	4 hrs	"	114
Harvest	260 hrs	"	7436
Cleaning residues	50 hrs	"	1430
Sub total			25929
Ground total			86451

Note: The Zambian currency unit "kw" is based on May, 1992 value. (US$ = 136 kw)

2) Sale value

Grain yield : 3 t/0.1 ha, Sale price : 80 kw/kg

Thus, sale value/0.1ha : 240000 kw

3) Balance/0.1ha

240000 kw - 86451 kw = 153549 kw

2.2.4 The Combination of the Cropping Pattern and Profitability

The combination of the cropping system depends upon the factors based on a farming scale of individual farm-households, labor availability, input materials and the market price of products. One attempt to draw a combination of cropping patterns and their profitability was prepared as follows;

If the prerequisite conditions of a individual farm-household is confined to 2 ha of irrigable field with 4 regular laborers, the model of the cropping pattern combination can be hypothesized as in Figure 2.2.1. Here, this model is designed to be a grain-based production system and vegetables as secondary crop from the point of view of the demand-supply situation. Furthermore it is planned that the single rice cropping system would be assigned to fields with thick peat-muck soil layers, and the double cropping system in fields with good irrigation-drainage conditions. The double cropping system would further be comprised of two cropping patterns of "early rice - cool dry season crop (wheat, onion" and "late rice - hot dry season crop (maize, tomato)" based on the seasonal apportionment of the labor input. The onion may be replaced with cabbage.

Managing a farm with this system, the necessary working hours per month are shown in Figure 2.2.2. Most of the time the system can be managed by family members (self-employees), except for the period from late March to early April when bird scaring and harvesting operations for early and late rice coincide and go beyond the capacity of family workers. Bird scaring, however, can be managed by getting assistance from kids or old men, or by taking a cooperative control method among farm-households who have neighbouring lands.

The profitability of running a farm management system with this crop combination is given in Table 2.2.27; of course, its profitability varies with harvest and the market price of that year. Thus this table is based on the profitability/unit area as per each guideline of the cropping pattern as of June in 1992, mentioned before in Sections 2.2.1 - 2.2.3. From these analyses, an annual balance of the presented model of the double cropping system produces 632,265 kw plus. Meanwhile, in the case of poor field conditions for both single cropping systems, the grain yield decreases to 4.5 t/ha and results in 534,024 kw plus.

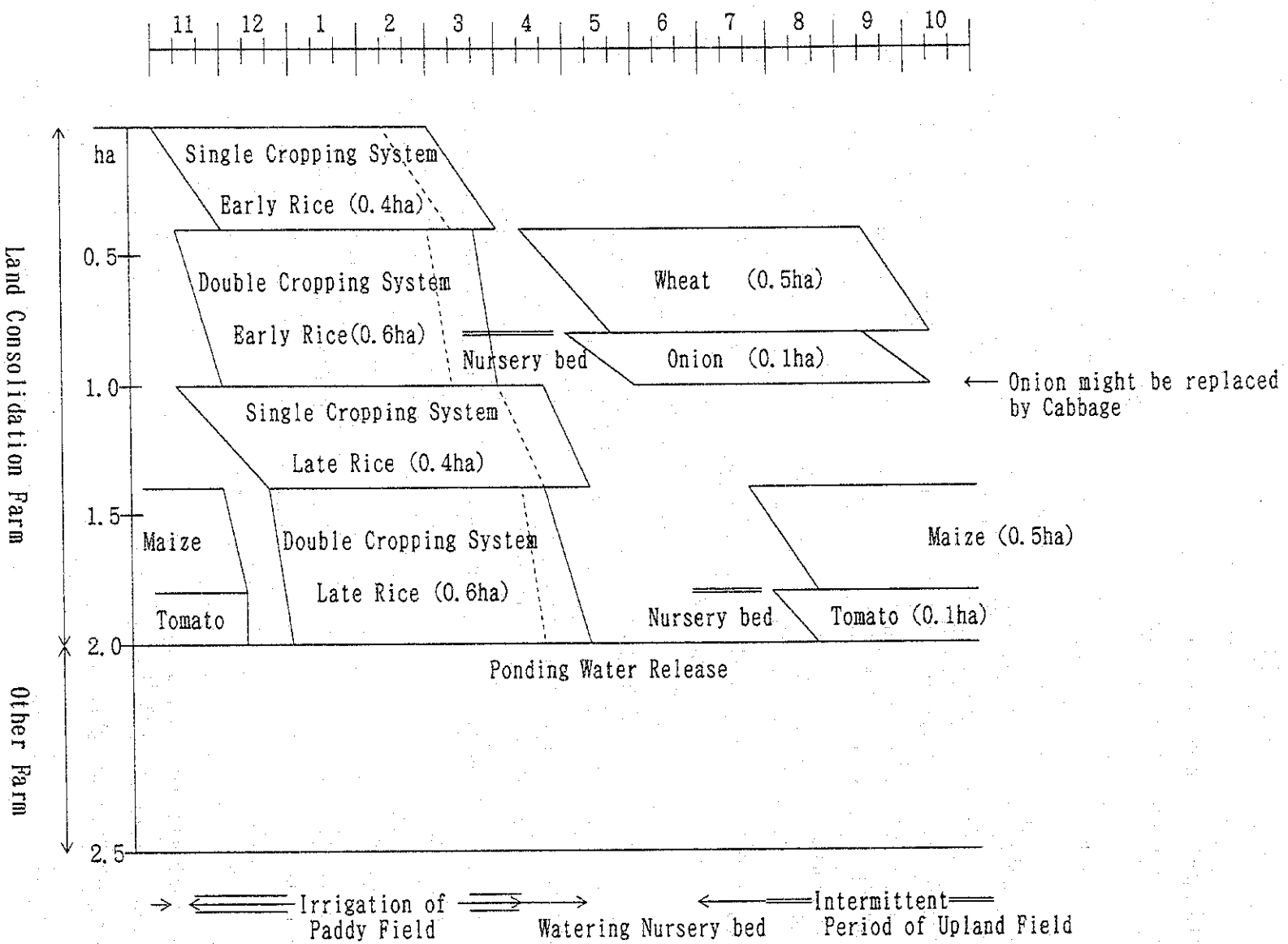


Figure 2.2.1 Model Plan of Utilization for the Land Consolidated Farm

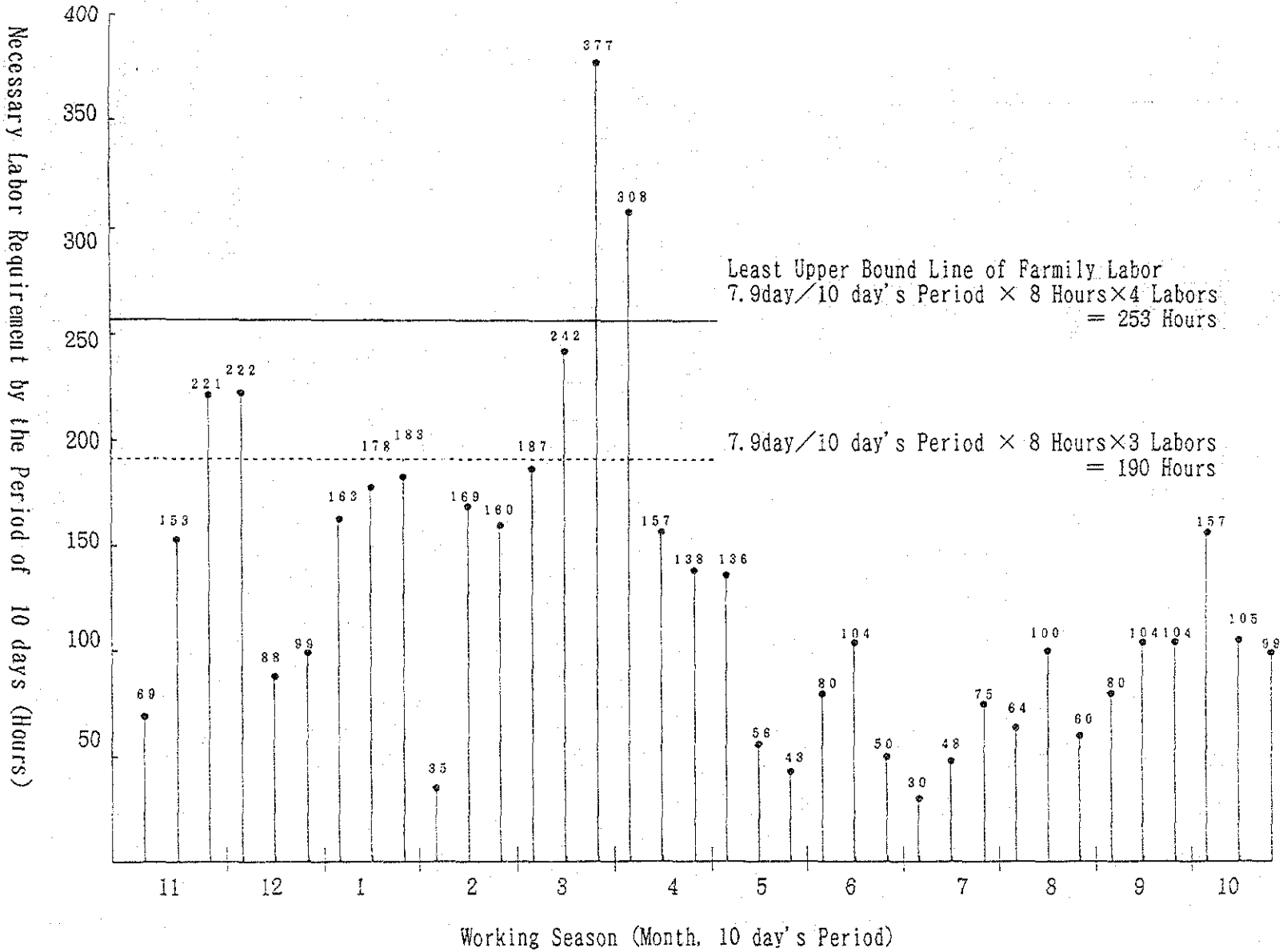


Figure 2.2.2 Total Labor Requirement (Hours) by Period of 10 days in the Combination Model of the Farming System

Table 2.2.27 The Profitability of the Combination Model among the Farming Systems

		Presented in the guideline			The combination model among the cropping systems	
		Target yield (t/ha)	Working hours (hrs/ha)	Balance (kw)	Cropping area (ha)	Balance (kw)
Single cropping of paddy rice						
Early rice	(GFC)	6	2,282	150,109	0.4	60,044
	(PFC)	4.5	2,102	102,157		(40,863)
Late rice	(GFC)	5.5	2,262	132,181	0.4	52,872
	(PFC)	4.5	2,102	102,157		(40,863)
Double cropping (Early rice - cool dry season crop)						
Early rice		5	2,132	122,199	0.6	73,319
Wheat		2.2	1,080	20,264	0.5	10,132
Onion		20	3,200	1,250,270	0.1	125,027
Double cropping (Late rice - hot dry season crop)						
Late rice		5	2,125	122,399	0.6	73,439
Maize		4	940	33,665	0.5	16,832
Tomato		30	8,940	1,535,490	0.1	153,549
Grand total					2.0	565,214

Note: 1. The working hours mentioned in the guideline does not include the farm operations of outside orders like oxen plowing or harrowing operations.
2. ( ) refers to a balance of the poor fields.
3. GFC: Good field conditions, PFC: Poor field conditions.

2.2.5 Verification of the Farming System in On-farm Lands

Based on the results achieved so far through the component technology trials, on-farm trials were carried out for 2 years from the 3rd year. The sites for the on-farm trials were located at the edge of the Zambezi flood-plain and at the outer plain, so-called "Saana" where alluvial soils predominated. The on-farm trials were conducted with direct sowing on dry soil under the following conditions: 60 kg/ha of seeds at a row space of 30 cm, using 250 kg/ha of D'mix for a basal dressing and 100 kg/ha of urea for a topdressing. Apart from the site in Sefula, the yield of Xiang Zhou 5, a short culm variety, ranged from 5.3 to 6.9 t/ha, while the yield of Angola Crystal, a long culm variety, was 3.8 to 5.6 t/ha (see Table 2.2.28). The yield in Sefula was low because of the initial growth being hindered by weed infestations, and bird damages at the ripening stage. On the other hand, Angola crystal at the Mabumbu site resulted in poor yields due

to panicle blast and stem borer damages during the ripening stage. Furthermore, the yield of Angola Crystal by quadrant sampling was 3.73 t/ha in the local field of Naela site.

Table 2.2.29 shows the result of the cost and return analyses in the Mabumbu on-farm trial. The direct cost refers to the actual expenditures paid by the host farmer with the exclusion of their own labor wage. Compared to the guidelines mentioned before, the labor cost of the host farmer as per farm operation was computed according to Table 2.2.2 and deducted this cost (24,100 kw) from the cost and return analysis table. As a result, the balance calculated showed a profit of 148,000 kw from Xiang Zhou 5 and 86,400 kw from Angola Crystal. These margin levels fairly agree with the profit of good fields (150,100 kw) and that of poor fields (102,100 kw) mentioned in the guideline.

From this point of view, the technology package of the rice presented in Section 2.2.1 is regarded as quite adaptable to local farming practices.

Table 2.2.28 The Result of On-farm Trials

On-farm site		90 - 91 season		91 - 92 season	
		Xiang Zhou 5	Angola Crystal	Xiang Zhou 5	Angola Crystal
Namushakende Farm Institute (NFI) (Sandy clay loam) Soil pH=4.4	GY (gm/m^2)	697	561	535	506
	CL (cm)	55.9 ± 4.7	89.6 ± 6.9	51.3 ± 3.2	89.7 ± 7.2
	G/S ratio	1.86	1.24	1.5	1.1
	GD (days)	116	118	125	132
Sefula on-farm trial (Sandy loam) Soil pH = 4.2	GY (gm/m^2)			300	300
	CL (cm)			44.6 ± 3.4	77.1 ± 11.3
	G/S ratio			1.1	0.58
	GD (days)			105	128
Mabumbu on-farm trial (Loamy sand) Soil pH=4.1	GY (gm/m^2)			543	376
	CL (cm)			49.3 ± 3.5	83.8 ± 9.7
	G/S ratio			0.92	0.36
	GD (days)			114	123
Naela on-farm trial (Sandy clay loam) Soil pH=4.5	GY (gm/m^2)	561	409	Failed to get any grain due to severe drought	
	CL (cm)	85.0 ± 4.7	123.0 ± 7.1		
	G/S ratio	0.65	0.51		
	GD (days)	114	119		
Local field at Naela site	GY (gm/m^2)		373		
	CL (cm)		95.7 ± 6.5		
	G/S ratio		0.78		

Note: GY; Grain Yield, CL; Culm Length, GD; Growth Duration
pH is based on $CaCl_2$ extraction.

Table 2.2.29 Cost - Return Analyses at Mabumbu On-Farm Trial (1992)

1) Expenditure

(kw/ha)

Direct cost	Amount of input	Unit price	Expenditure	
			Xiang Zhou 5	Angola Crystal
Fertiliser				
D'mix (10-20-10)	250 kg	16	4,000	4,000
Urea	100 kg	16	1,600	1,600
Sub total			5,600	5,600
Materials				
Seeds	60 kg	37.5 kw/kg	2,250	2,250
Jute bag	50 - 70 bags	50 kw/bag	3,500	2,500
Sub total			5,750	4,750
Labor				
Plowing (oxen)	1 ha		5,200	5,200
Harrowing (oxen)	1 ha			
Leveling			4,000	4,000
Sowing	87 hrs	28.6 kw/hr	2,488	2,488
Fertiliser	10 hrs	28.6 kw/hr	286	286
Weeding			8,000	8,000
Water management		(Self-employee)	-	-
Bird scaring		(Self-employee)	-	-
Harvest		(Self-employee)	-	-
Winnowing		(Self-employee)	-	-
Sub total			19,974	19,974
Grand total			31,324	30,324

2) Sales value (ha)

Xiang Zhou 5: 5,245 kg/ha, 80 kg bag for sale = 3,000 kw

5,425/80 x 3,000 = 203,438 kw/ha

Angola Crystal: 3,762 kg/ha, 80 kg bag for sale = 3,000 kw

3,762/80 x 3,000 = 141,075 kw

3) Balance/ha

Xiang Zhou 5 = 203,438 - 31,324 = 172,114

Angola Crystal = 141,075 - 30,324 = 110,751

Note: Zambian currency "kw" is based on May, 1992 basis (US$ = 136 kw).

2.3 Guideline of Useful Component Technology

2.3.1 Line maker and Drill Seeder for Paddy Rice

(1) Line maker

Rice seed drilling is locally conducted by dropping seeds along ditches formed after oxen plowing, and then harrowing the field to cover seeds with the soil. This extensive cultivation technique is partially adopted in some of the areas in the Western province, but the methods involved lack uniformity in terms of row spaces and emergence. Thus, a line maker which can adjust a row space of 25 and 30 cm and make 3 lines at the same time was invented.

This trial product is shaped like a dragonfly as shown in Figure 2.3.1. The method of making seeding furrows with this tool is to pull the handle with both hands by putting one or two blocks on top of the weight holder to exert pressure needed for making the ditch. Further, the efficient use of this tool and the systematic drawing of lines would require 3 workers: two for marking row spaces on both sides of the field and tightening the tips of the string bounded with pegs over the marks on both sides, and one to pull the tool along the string. This tool can also be operated by one person if manpower is limited. The operation test conducted on this tool showed the following results:

1) Advantage

Possible adjustment of row space to 25 or 30 cm and making 3 ditches simultaneously. Superior to the former method employed which made ditches by using a peg along a string tightened on both sides.

2) Disadvantage

a) Frequent removal of silty or clayey soil which sticks to the nails of the tool at operation when the stickiness of top soil increases due to rainwater.

b) Difficulty in seed furrow making when numerous fist-sized clods remain in the field due to inadequate harrowing.

c) Difficulty in seed furrow making as the nails only slide on the surface even with the stone blocks when top soil becomes compact after being exposed to dry and wet conditions following plowing operation.

3) Necessary improvements

The nails should be bent towards the direction of pulling and the nail tips sharpened to enable the making of ditches even on compacted or hardened soil.

(2) *Drill seeder for paddy rice grain*

Although transplanting and drilling methods have been adopted in some areas in the Mongu district, the lack in technical skills and the longer working hours involved make it difficult to convince the farmers of the advantages of the line sowing method, when yield and crop factors are considered, over the broadcasting method. To solve such problems that would hinder the popularisation of the drilling method, a manual drill seeder was made by installing hoppers to the line maker and by revolving a seed roller in accordance with the spike wheel's movement to play out grain seeds from hoppers (see Figure 2.3.2). All the materials required for making this tool were locally acquired and manufactured in the local workshop. As a result of repeated sowing tests in the Namushakende field for improvement, it reached a practical use level. Hence, with the improvement of points in future, the manual drill seeder for rice grains can be suited to small scale farmers and then can be extended for local production.

The following are results achieved from the test of the drill seeder:

1) Specification

3 line drill seeder (30 cm row space), seed rate: approx. 48 kg/ha, capacity of seed hopper: approx. 3 liters/one x 3 = 9 liters (equivalent to 5 kg of seeds)

2) Moot points arising from the drilling operation

a) The type of soil that causes difficulty is same as the line maker.

b) Rachises often block the downward movement of the seeds to the hole of the seed roller via the hopper. It is, therefore, important to get rid of them beforehand by strictly winnowing and screening rice seeds with water.

c) The absence of an agitator in the hopper might hamper the smooth downward movement of the rice seeds by gravity. One worker should, therefore, follow the drill seeder to monitor the hoppers and to shake it slightly to prevent clogging.

3) Necessary improvements

a) With the aid of the spike's movement, the installation of an agitator will ease off the downward movement of the seeds in the hopper and would result in a more uniformed sowing.

b) A ridging board should be added to complete the whole sowing operation at one time.

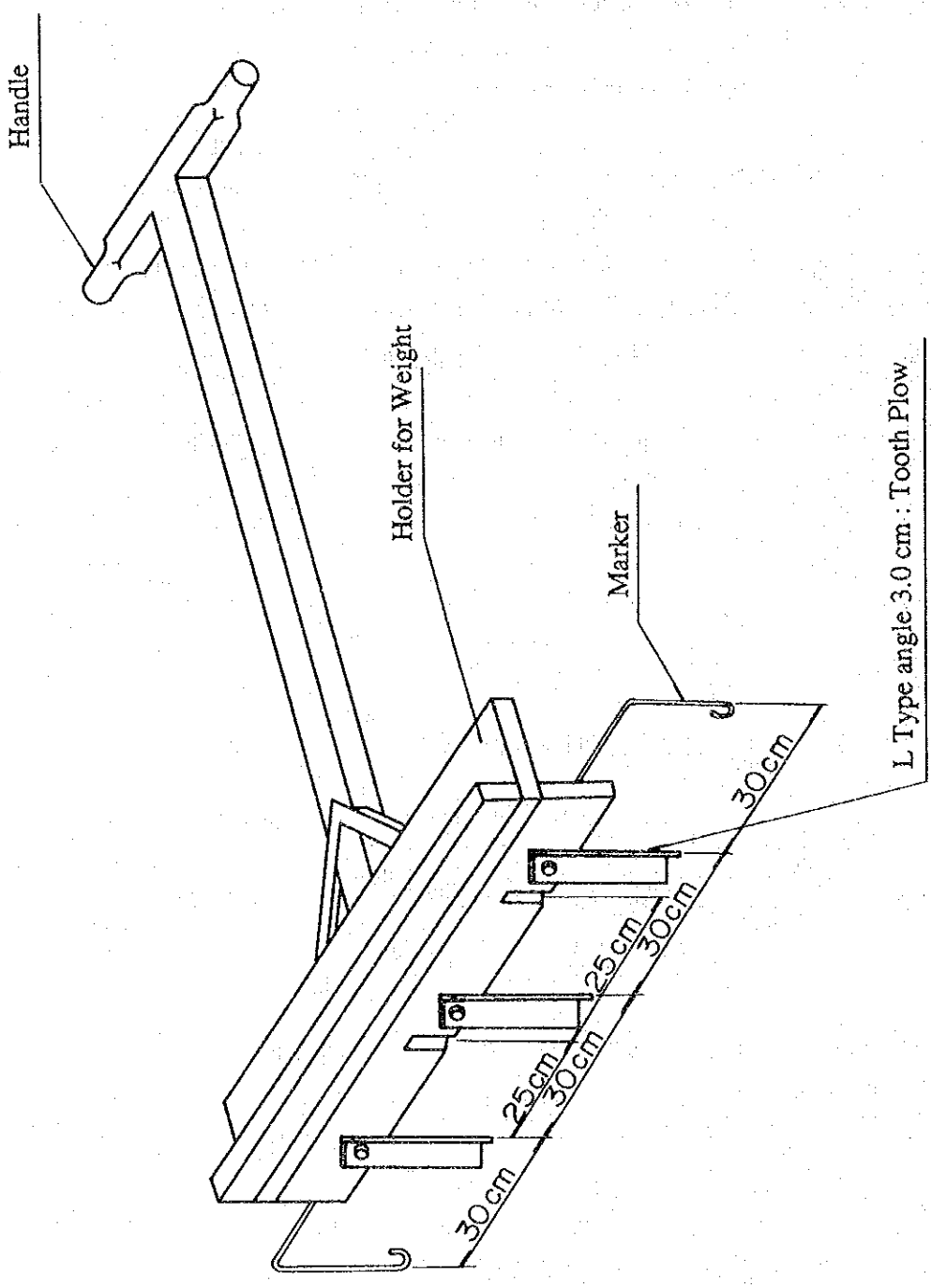


Figure 2.3.1 Line maker

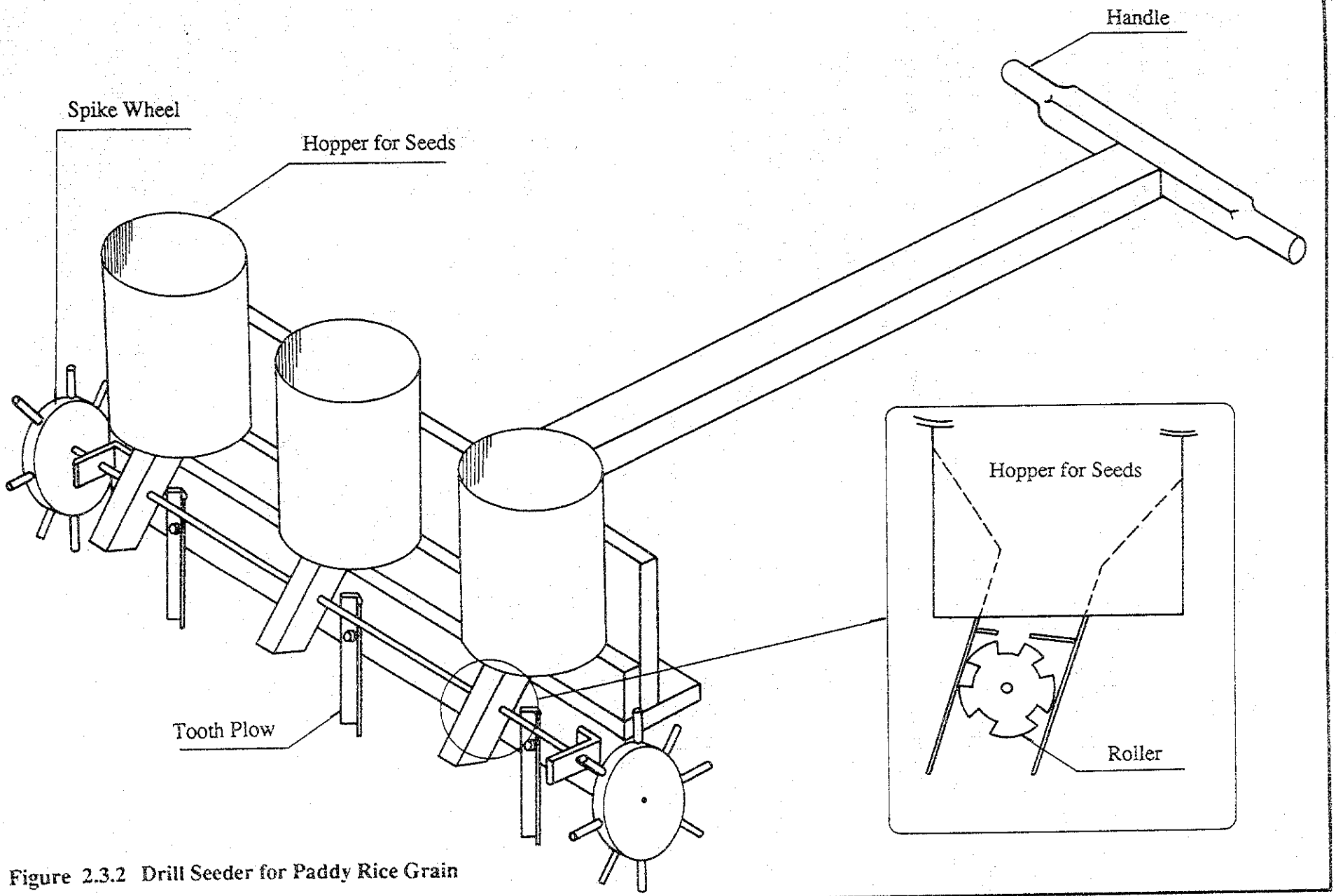


Figure 2.3.2 Drill Seeder for Paddy Rice Grain

2.3.2 Sowing Methods in Sandy Soil

The sandy soils in Lealui is poor in organic matter and has low water holding capacity. Crop watering is essential in the dry season, but after watering the soil dries up rapidly resulting in uneven emergence and the poor growth of seedlings. The trials for some improved sowing methods were conducted to verify their effectiveness.

(1) Furrow planting (Seeding at the bottom of the ditch)

At first, make furrows 7~8 cm deep along the ridge and then cover the seeds with only 2~3 cm of soil (Figure 2.3.3). With this method irrigation water stays in the hollow parts preventing the drying of the seed and leading therefore to a good germination and also good growth with effective water use.

Table 2.3.1 Growth and Yield of Furrow Planted Crops (1989)

Crops/Varieties	Sowing methods	Harvested date	Fresh wt. of top t/ha	Dry wt. of grain t/ha
Maize	Furrow	Dec. 6	16.0	4.00
(MMV400)	Level	Dec. 7	12.5	1.17
Millet	Furrow	Dec. 3	23.5	4.34
(ICMV82/32)	Level	Dec. 5	13.3	2.17
Sorghum	Furrow	Dec. 6	13.4	2.21
(WSV387)	Level	Dec. 12	10.7	0.71

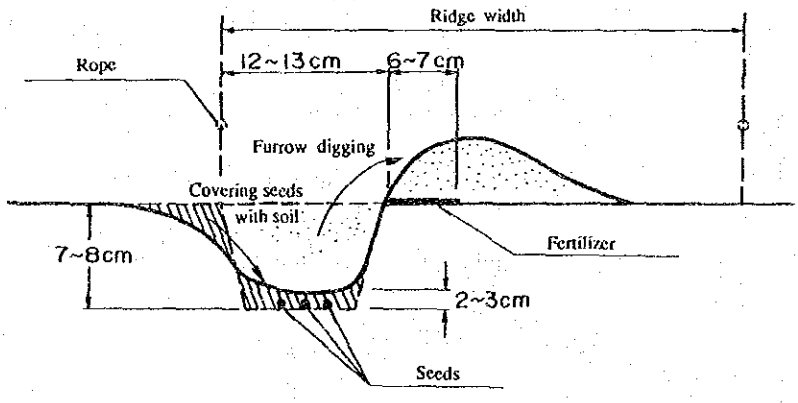


Figure 2.3.3 Fertilizer Application and Furrow Making

(2) Mulching with grass after sowing

This operation is done as follows: after sowing, apply water on soil and mulch the furrow with dry grass of 20 ~ 30 cm width. In the flood plain it is easy to get grass for mulching, and even in the dry season wilted wild grass can be used. Maize seeds may emerge through the dry grass by themselves, but it is necessary to make slits in the grass to promote the emergence of seedlings in the case of sorghum and beans.

The application of grass mulching clearly promotes good emergence and growth and subsequently good yield. The results from the verification trials in Lealui are shown in Table 2.3.2. Soil temperatures at 3 cm depth for the mulch plots are 3°C~4°C lower than the non mulched plots. The delayed drying of surface soil is also associated with the former plots. With these facts it can be said that grass mulching controls excess soil temperatures and evapotranspiration and promotes good growth.

Table 2.3.2 Effect of Grass Mulching on Growth and Yield of Maize (Variety MM504) (1990)

	Days after sowing		Maturing date	Culm height cm	Grain yield t/ha
	12	30			
	Emergence (%)				
Mulching Level		78	Dec. 19	83	2.004
Non mulching level	42	75	Dec. 17	82	1.351
Mulching furrow		81	Dec. 19	85	1.765
Non mulching furrow	76	76	Dec. 17	86	1.697

Note: Sowing date August 20

(3) Fertilizer application method on sandy soil

In sandy soil where water percolation is high, the potential for fertilizer leaching is also high, thus requiring two or three times the split fertilizer application. However, sometimes the occurrence of germination injury is observed due to the proximity between seeds and fertilizer. As a countermeasure, it is effective to combine this fertilizer application method with the aforementioned furrow planting method. The operation is done as follows: ① to stretch a rope along the fixed ridge, ② about 12 cm apart from the rope, to put fertilizer with 6~7 cm width, ③ between the rope and fertilized portion, to dig furrow with about 8 cm depth and put the soil on the fertilizer shaping as shown Figure 2.3.3, ④ to sow

the seeds at the bottom of the furrow, then cover the seeds with the soil taken from the opposite side of the furrow between the rope. The depth of the covered soil on the seeds is 3 cm in case of maize.

Table 2.3.3 Relationship Between Emergence and Position of Fertilizer in Sandy Soil (1991)

Plot	Non fertilizer	Furrow fertilized		Near furrow side dressing of fertilizer
		Without soil between seed & fertilizer	With soil between seed & fertilizer	
Emergence %	81.0	60.4	70.0	85.4

Note) Crop: Millet (Variety LBC)
Fertilizer: D'mix (10-20-10) 200 kg/ha
Sowing date: Sept. 1

2.3.3 Sowing Methods in Peat-muck Soil after Burning

(1) Sowing after burning

In these areas, there is a traditional method which consists of burning weeds prior to seeding. During the study we examined the effects of this burning on crop production.

In the Namushakende farm, in August 1990 to May 1991 fallow plots were used. In the plots without burning, all the weeds were cut and taken away. In the plots with burning, the top of the weeds were burned early in June and the roots from the middle to the end of July when they were dug out from the soil at the time of plowing. The ash was scattered over the plot. The dry weight of the top of the weeds was 3.4 t/ha and the ash weight was 380 kg/ha according to the measurement done late in May.

The improvement rate of soil chemical properties and the growth of maize with the use of grass ash was as follows:

pH: Before burning it was 4.9 on 29th May with no difference between the plots, and changed depending on treatments to 5.4 in non treated and 5.8 in grass ash plots on 15th September, one month after sowing. In the 500 kg/ha liming plot it was 6.0, a similar amount being recorded in the grass ash plot.

Soil analysis: although soil sampling was delayed until the 1st December, there were some differences between plots as related to the concentration of total P, available P, and potassium with twice more in the grass ash plot than in the non treated plot. In addition the grass ash plot contained more Zn and Mn than the non treated plot (Table 2.3.4). These results showed that a considerable amount of minerals from the weeds was returned back to the soil.

The effects of grass ash on the growth of maize: maize growth was accelerated in the grass ash plot resulting in the improvement of yield components; namely the number of fertile ears (Table 2.3.5). Especially in the plot with grass ash and fertilizer applications which gave the highest yield due to the combined effect of grass ash and the chemical fertilizer.

From these results, it can be said that the traditional grass burning method is effective in amending acidity and in increasing minerals in the soil, resulting in higher yields for crops. In practicing this method, the application of chemical fertilizers must be considered for better effects.

Table 2.3.4 Chemical Analysis of Grass Ash Applied and Non Applied Soil (Sampled on Dec. 1)

	T.C	T.N	T.P	K	Available P	Ex. Ca	Mg	Zn	Mn	CEC	pH
	%	%	me/100g	me/100g	ppm	me/100g	mg/100g	ppm	ppm	me/100g	(KCl)
Grass ash	14.5	0.23	205	0.36	89	8.4	1.3	12.7	15.0	43.2	4.1
Non	14.0	0.44	112	0.15	49	9.4	1.4	10.3	10.7	42.2	4.2

Note: Analyzed by Mount Makulu Central Research Station

Table 2.3.5 Growth and Yield of Maize in Mucky Soil Treated with Grass Ash

	Grass burned		Non grass ash		
	Only grass ash	Grass ash + fertilizer	Lime 0.5t + fertilizer	Lime 1t + fertilizer	Nil
Culm length (cm)	123	134	133	125	100
Fresh wt. of one plant (g)	271	358	410	333	219
No. of fertile cob/plant	0.52	0.92	0.55	0.51	0.08
Yield of dry grain (kg/ha)	1,467	2,723	1,741	1,403	92

Note: Fertilizer; D'mix 300 kg/ha, Urea (topdressing) 100 kg/ha

(2) Utilization of rice straw ash in rice cultivation

Rice is relatively tolerant to acidic soil, but the peat-muck soils in Namushakende are so acidic that sometimes the rice plants are killed by the high acidity. Table 2.3.6 shows the results of the trials conducted in the plots during the second year after the construction of the farms. From these results, rice straw ash showed some effects although inferior to the plots with 1.5 t/ha lime applications. The following year, as shown in Table 2.3.7, rice ash plots showed almost the same effect as the lime plots.

In general lime is used for acidity amendments, but in this area it is sometimes difficult to get it for farmers. From the above mentioned results, rice straw ash is considered as a right substitute to lime. Although rice straw is an important feeding material, it can be used sometimes for soil improvement when it is difficult to get lime.

Table 2.3.6 Effect of Rice Straw Ash and Lime on Rice (1990-91)

Amount of applied material		Grain yield	Main culm length	Grain/straw ratio
89 - 90	90 - 91	g/m^2	cm	
0	Rice straw ash (Dry straw 5.5t)	100	41	0.22
0	Lime 1.5t	138	44	0.27
0	0	43	33	0.12

Note: Fertilizer; Basal D'mix 300 kg/ha, Topdressing urea 100 kg/ha

Table 2.3.7 Effect of Rice Straw Ash and Lime on Rice (1991-92)

Amount of applied material			Grain yield	Main culm length	Grain/straw ratio
89 - 90	90 - 91	91 - 92	g/m^2	cm	
0	Lime 1.5t	Lime 1.5t	382	56	0.78
0	Rice straw ash (Dry straw 5.5t)	Rice straw ash (Dry straw 5.5t)	387	56	1.09
0	0	0	286	46	0.92

Note: Same as Table 2.3.6.

2.3.4 Rice Straw Incorporation on Paddy Rice

Peat-muck soils, which are strongly acidic, dominate the Sishanjo band located at the edge of the Zambezi floodplain. Akiochi symptom characterised by brown spots is usually observed during the late growth stage of the rice plants due to the deficiency of fertiliser elements. Among the soil improvement trials where the input of various soil conditioners took place, the effect of rice straw showed the most significant effects in terms of yield increases and resistance against diseases. Accordingly, a study on the effect of rice straw was made on soil chemical properties and plant tissue aspects with plant growth.

The test plots were thickly distributed with peak-muck soil and allocated to 1) the plot half dressed with sand during the cool dry season in 1989, and 2) the plot was used for single cropping system of early maturing rice. This time, rice straw was scattered in the field during the cool dry season (May - June 1991) after the completion of rice cropping, and were incorporated in the field during the hot dry season (July - October 1991) by plowing the field thrice to accelerate the decomposition process. About 4,000 kg/ha of rice straw was used. Lime and fertiliser applications were completed before planting which was conducted through the transplanting and direct sowing on dry soil.

(1) Effect of rice straw incorporation on soil chemical aspects

Soils sampling in the test plots was conducted during the tillering stage when significant differences were seen among the treatments. The result of the chemical analysis indicated a 2 - 4 times higher content of P, K, and Mg in the plots treated with rice straw as compared to the control plot (see Table 2.3.8).

Table 2.3.8 The Result of Soil Chemical Analysis (E-1-2: Peat-muck Soils)

No.	Treat.	NH_4	P	K	Ca	Mg	Na	Zn	Mn	Cu	Fe	CEC	pH
		ppm	ppm	me/100g	me/100g	me/100g	me/100g	ppm	ppm	ppm	ppm	me/100g	$CaCl_2$
1	+ straw	3.7	60	0.24	6.2	2.1	0.10	130	20	4.0	1,160	71.7	3.8
2	+ straw	4.8	31	0.12	3.4	1.8	0.10	860	22	5.0	1,470	69.9	3.8
3	- straw	4.9	17	0.09	1.4	0.5	0.07	1,190	14	6.0	1,100	73.3	3.6
4	- straw	5.0	24	0.08	3.4	0.9	0.06	450	20	2.0	1,120	63.1	3.9

(by Mount Makulu Central Research Station)

(2) Effect of rice straw incorporation on leaf tissue element

Table 2.3.9 shows the results of the tissue analysis of the flag leaves of the early maturing variety in the single cropping system trial. The N-concentration of the flag leaves at the tillering stage is said to be 2.5% as a threshold value between normal and deficiency. The N-content of the flag leaves in the plots treated with rice straw resulted in 56% higher than that of control plots in a pooled mean. Other elements showed no significant difference. Silica elements were not analysed due to technical difficulties, but it was reported that a deficiency of silica during the late growth stage caused a drop in the number of spikelets per panicle and the percentage of filled grains, consequently leading to a sharp drop of grain yield. Thus, it was assumed that a marked amount of silica was supplied through rice straw incorporation based on a rate of yield increase.

Table 2.3.9 The Result of Tissue Analysis of the Flag Leaves (M-6-1/M-6-2 Peat-muck Soils)

No.	Treat.	N	P	K	Ca	Mg	Zn	Cu	Mn	B	Si
		%	%	%	%	%	ppm	ppm	ppm	ppm	ppm
1	+ Straw	2.3	0.22	0.92	0.61	0.18	29	5	81	7.0	NA
2	+ Straw	2.7	0.22	1.10	0.32	0.15	27	0	89	4.5	NA
3	- Straw	1.4	0.14	0.87	0.55	0.23	30	5	86	-	NA
4	- Straw	1.8	0.21	0.90	0.89	0.19	25	5	92	8.1	NA

NA: not analysed (by Mount Makulu Central Research Station)

(3) Effect of rice straw incorporation on plant growth and grain yield

Tables 2.3.10 and 2.3.11 show the final results on growth and yield. Table 2.3.10 refers to the soil improvement trials. The growth of the rice plants was vigorous in the plot with the rice straw treatment, which showed no dying off from lower leaves and no discoloration from leaf tips. Meanwhile, discoloration symptoms were observed in the control plots from the tillering stage, where brown spot also severely infested the plants at the heading stage. Furthermore, a severe panicle blast was widely spread at the ripening stage, resulting in a sharp reduction of grain yield. The occurrence of panicle blast in the control plot was related to the amount of silica supplied naturally because the plots treated with rice straws showed no symptom of blast at any stage.

The effect of rice straw incorporation in yield was 145% increase in the test plots with sand dressing(see Table 2.3.10), and 43 % increase in the test plots with peat-muck soils (see Table 2.1.3). In the single cropping system trial of the early maturing variety, a 53% increase was recorded as compared with the control plots (see Table 2.3.11).

Table 2.3.10 The Results of Rice Straw Incorporation Trial (91-92)
Test plot : E-1-1 field with sand dressed

Treatment	Grain yield (gm/m^2)	No of Panicles ($/m^2$)	G/S ratio	Culm Length (cm)
+ Straws	539	189	1.34	50.2 ± 4.3
– Straws	220	139	0.95	37.8 ± 44.6

Treatment effect is significant at 5 % level. $LSD_{0.05} = 309.8\ gm/m^2$
Test variety : P1369

Table 2.3.11 The Effect of Rice Straw Incorporation on Single Cropping System of Early Maturing Rice (91-92)

Treatment (Field)	Grain yield (gm/m^2)	No of Panicles ($/m^2$)	G/S ratio	Culm Length (cm)	Growth Duration
M-6-1	471	248	1.18	49.9	117 (days)
M-6-2 (+ Straws)	720	315	1.5	52	115 (days)

Test variety : Xiang Zhou 5

(4) Summary

According to the trial results shown above, the effect of rice straw incorporation on yield increase is highly significant. Namely it was verified that incorporating rice straws in the field had the effect to increase N-content of the leaves, phosphate, potassium and magnesium contents in the soils, and further to increase the resistance against blast and brown spot disease.

The standard amount of rice straws to be incorporated in a plot may be equivalent to the amount of rice straws harvested from the plot. If these rice straws do not decompose, temporal N-deficiency symptom might occur after planting. It is, therefore, recommended to conduct winter plowing operations 2 or 3 times to accelerate the decomposition of rice straws.

Under a field with poor drainage conditions, the rice straw incorporation plays a negative effect, thus a careful attention should be paid concerning this point.

Boosting grain yield with chemical fertilizers may impose a burden on small scale farmers in terms of production cost, but the incorporation of nice straws will only require additional labor cost, while providing all the elements necessary for plant growth. Conclusively, this method is considered to be useful to small-scale farmers.

In the Western Province, residues of cereal crops have been utilized as feed; however, considering the proposed model cropping plan in the consolidated field (section 2.2.4), the rice fields (where rice straw incorporation technique is applied) occupy only 27% of the total acreage for cereal crop cultivation and seems to be less competitive with feed supply.

2.4 Countermeasures for the Constraints of Crop Production

2.4.1 Improvement of Peat-Muck Soil

The peat-muck soil, which are widely distributed in the Namushakende farm are highly acidic, especially in the E and M fields series located by the Musiamo Canal where soil horizons cover up to 60 - 100 cm depth and where pH values are 3.9 - 4.4.

Crops cultivated in these soils show growth abnormalities such as, decrease in nutrient absorption due to high soil acidity, damages resulting from the organic acids produced by the decomposition of organic matters in the soil, and other damages resulting from micro-nutrient deficiency. Generally, these symptoms, which slightly differ according to crop, can be detected from the change of leaf color to yellow-green or yellow-brown, restrained growth, poor heading or appearance of white heads, or sometimes from withering. On the other hand, they can also be detected from the unfavorable growth of the roots, as in the case of some maize crops where the roots are distributed only at the uppermost soil layers, within depths of less than 8 cm. These situations considerably reduce yield or sometimes produce no harvest at all.

Therefore, to improve soil chemical properties and crop yield, trials were carried out to find out effective countermeasures against the factors causing growth damages.

Peat-muck soil improvement trials including rice straw incorporation discussed in section 2.3.4 "Rice Straw Incorporation on Paddy Rice", were mostly carried out without replications. However, from the results of the chemical analysis on soils and plants, the effects of the counter measures were clear.

In the future, studies on the improvement of peat-muck soils to increase and stabilize productivity should be continued.

(1) Amelioration of soil acidity by lime application

Although lime application initially raises the pH value of the soil, this pH could again decrease during the growth process (see Table 2.4.1).

Table 2.4.1 Effect of Lime Application for Soil Acidity

Field		Lime application amount (t/ha)			
		0	1	2	3
E-5-1[1)]	pH[4)]	3.9	4.1	4.2	4.9
M-4-2[2)]	pH[4)]	4.1	5.2		6.5
M-4-2[3)]	pH[4)]	4.4	3.9		5.0

Note: 1) 4 months after application (flooded field)
2) 2 months after application (drying field)
3) 4 months after application (drying field)
4) Measured by $CaCl_2$ extraction

For this soil type, the pH amelioration through lime application generally hastens plant growth and increases yield. A single lime application, however, does not increase the yield of wheat and maize, as the former requires the joint application of lime and copper and the latter requires the joint application of lime and zinc.

The effectiveness of lime application in rice fields was shown when yield increases of 3 - 3.5 tons/ha were obtained through the application of 1 - 3 tons/ha of lime, and when no yield was observed in the E-5-1 field where lime was not applied. Regardless of the discrepancy in the volume of lime applied and the pH values, the yield increases were the same (see Table 2.4.2). The residual effect of lime was detected 2 years after this application, and the yield observed in this plot was approximately 70% of the yield of the plot where lime was again applied on the second year (see Table 2.4.3).

Table 2.4.2 Effect of Lime Application on Rice Yield (Variety: IR 8192)

Lime application amount t/ha	Grain yield t/ha
0	0
1	3.58
2	3.14
3	3.16

Table 2.4.3 Residual Effect of Lime Application on Rice Yield (Variety: IR 8192)

Lime application amount		Paddy yield (t/ha)
1st year (t/ha)	2nd year (t/ha)	
1 ~ 3	1.5	2.25
1 ~ 3	0	1.53
0	0	0.43

(2) Effect of copper application on wheat

It was observed that wheat cultivated in the E and M fields of Namushakende showed symptoms of chlorosis, growth stagnation and appearance of white heads, etc. With the application of copper sulfate, however, none of these were observed and yields increased. Based on the experimental results, the optimum amount of copper sulfate to be applied was 20 - 30 kg/ha (see Table 2.1.7).

Copper sulfate is mixed with soil at 1 to 10 weight ratio. The mixture is then applied uniformly on the field right before seeding and is mixed with the surface soil. The uniform application of copper sulfate is very important, otherwise excessive damage may occur in areas where large amounts are applied.

However, the application of copper sulfate was found ineffective with maize crops.

(3) Effect of zinc application on maize

It was observed that maize cultivated in the E and M fields of Namushakende showed symptoms of chlorosis (yellowing of leaves), growth stagnation, late and poor development of cobs, and sometimes sterility. With the application of zinc sulfate, however, none of these were observed and yields increased (see Table 2.4.4).

Based on the experimental results, the optimum amount of zinc sulfate to be applied was 20 kg/ha. However, no effect was observed when zinc was not applied together with lime. Further, the application of zinc in fields cultivated with wheat was found ineffective.

Table 2.4.4 Relationship between Maize Yield and Application Amount of Zinc sulfate and Lime

Treatment	Number of days to heading			Length of stem cm			Grain yield kg/ha		
	Lime 3t	1t	0	3t	1t	0	3t	1t	0
(Pool 16)									
$ZnSO_4$	73	72	72	91.6	78.6	82.5	1,940	1,094	964
No treatment	90	86	86	74.0	63.9	69.3	503	581	438
(MMV400)									
$ZnSO_4$	77	76	82	101.5	90.5	86.9	1,172	1,275	1,042
No treatment	93	88	93	76.5	72.1	67.3	496	748	347

Zinc is applied by mixing it with soil weighing ten times more than it does. The mixture is then drilled together with the fertilizer right before seeding.

(4) Soil improvement by soil drying through plowing and incorporation of rice straw

In the hot dry season, maize sown after drying the peat-muck soil followed by a deep plowing operation(15 cm) gave better growth than maize sown after a shallow tillage. This suggests that the treatment of deep plowing and drying generates the dehydration and oxidation of the top soil layer and appears to improve a soil environmental for root development.

Also, as described in section 2.3.4 "Rice Straw Incorporation on Paddy Rice", minerals, especially silica, are supplied when rice straw is completely decomposed under aerobic condition, thus resulting in the double effects of soil aeration and minerals supply.

(5) Conclusion

The methods to increase the yields of crops cultivated in the Namushakende farms, where highly acidic peat-muck soils are widely distributed, vary according to crops. However, the amelioration of soil acidity (pH) through the sole application of 1.5 - 3 t/ha of lime can be achieved regardless of the kind of crops'. This liming method can increase paddy yield, while the joint application of lime and copper (30 kg/ha) on wheat fields and lime and zinc on maize fields (30 kg/ha) can result in normal growth and yield increase. Also, if the field is well drained and completely dry conditions during the dry season, a mineral

supply is expected through the aerated decomposition process of incorporated rice straw.

On the other hand, sand dressing application was found ineffective, as its application of 700 m^3/ha, together with fertilizer, at the E-1 field only produced a yield of 300 kg and 150 kg for wheat and maize, respectively.

2.4.2 Improvement of Sandy Soil

The sandy soils of Lealui farm originated from the Kalahari Sand (0.2 - 2 mm in size), which is characterized by a high water permeability, low water retention capacity, and low organic matter content. Crop cultivation in this area during the dry season requires large amount of irrigation water and frequent topdressing application. To curtail labor cost and yet achieve high crop yield, methods to improve the physical property of sandy soil were studied. Several materials including black soil, bentonite, and water absorbent polymer were tested for the improvement of sandy soils, and some good results were obtained. Only the results on the black soil dressing application will be explained here. Those concerning the bentonite and the water absorbent polymer applications are discussed in the Appendix as these two materials are not available in Zambia.

The application of 300 m^3/ha of black silty soil collected from the lowland area near the Lealui Farm indicated that although an increase in soil fertility was not observed, the increased retention of chemical nutrients and the delayed occurrence of deficiency symptoms were achieved, thus making the reduction of the top dressing dosage possible.

Moreover, the application of black silty soil increased the yields of maize and millet crops when combined with 2500 kg/ha of dried cow dung and 400 kg/ha of D'mix (10-20-10) as basal dressing, and 200 kg/ha of D'mix as top dressing (see Table 2.4.5).

Table 2.4.5 Effect of Black Silty Soil Dressing on Maize and Pearl Millet (1989)

Crop	Variety	Fresh weight of shoot (kg/ha)		Grain yield (kg/ha)	
		No dressing	Dressing	No dressing	Dressing
Maize	MMV400	7,600	21,500	612	2,500
Maize	MMV600	12,500	19500	1,170	1,780
Maize	MM 604	11,800	21,000	360	3,450
Millet	ICMV8283	6,100	9,600	1,280	1,670
Millet	NC-D2	6,600	11,700	1,190	1,280

The residual effect of black silty soil dressing was observed on the yields of rice cultivated in 1989/90 and 1990/91 (see Table 2.4.6).

Table 2.4.6 Residual Effect of Black Silty Soil Dressing on Rice Yield

Cropping year	No dressing kg/ha	Dressing kg/ha
1989/90	2,300	3,672
1990/91	2,122	3,126

2.4.3 Crop Protection

The farming systems have been studied under a basic plan minimizing the use of agricultural chemicals, but in certain cases of disease and insect pest occurrence the use of chemicals should be considered.

(1) Insect, rat, bird and Weed control for rice

1) Black maize beetles (Heteronychus spp)

This is a beetle with 12 ~ 18 mm length living several cm deep below the soil surface. It feeds on leaf sheath of young seedlings of graminae causing death.

In case of direct sowing of rice plants, the plants are damaged in the young stage during the upland condition between emergence and the apparition of three or four leaves age. In the Sishanjo area with humid muck soil, the

damage is observed almost every year. The best way to control the insects is to flood the field.

The seed dressing with Sumithion powder is effective but one should consider the possibility of the powder being leached by rain.

2) Rice plants are attacked by rats in the young seedling stage from emergence to weaning (almost all nutrients in the seeds are lost), and in the ripening stage from dough stage to harvest. It is important to keep rat density lower by weeding in the surroundings of the field and also by setting traps. When using chemicals, very careful attention must be paid to the pollution of canals, especially rainfall runoff. In our study, scattering paddy as lure crop in the surroundings of the field at the time of emergence was effective.

3) Weed control

Directly sown rice plants compete with weeds during the dry land conditions before irrigation, and sometimes weeds may dominate. To control weeds, in the case of single cropping of rice, it is effective to plow or till during the dry season. In case of double cropping of rice and upland crops in general, weeds are restricted. As a rule of thumb, it is important to control weeds at their young stage by tillage operations.

4) Bird control

In rice direct sowing, bird damages can mainly occur during two periods: namely, the sowing period (especially on wet soils as seeds are directly sown without being buried), and from the milky to the harvest period. Bird damages are negligible in the case of direct sowing on dry soils as seeds are buried, however, the stage after flowering usually invites severe damages unless countermeasures such as practicing bird scaring operations on the field are taken. For example, on one of the on-farm trial site in Sefula, 40% reduction of grain yield was recorded due to the failure of the farmers to conduct these operations themselves. Further, it was observed that birds targeted only the tested field because of its early maturity among the late maturing variety growth in the surrounding fields. The best time to organize the bird scaring operations is from 6 a.m. to sunset. The physical presence of farmers is more reliable as the test of scarecrow did not lead to any quantitatively clear results.

(2) Rat control for wheat

Wheat cultivated in the cool dry season was usually attacked by few pests and diseases, but is severely damaged by rats in a certain growth stage. As rats attack other cereals like rice or maize, the control is effective by reducing the populations through weeding or trapping.

(3) Disease and pest control for maize and sweetcorn

In the dry season in general, there are few damages by disease and pest, except rats and maize stalk borer eating into the cob.

The rat damages on germinated seeds and young seedlings are severe in the dry season, and as mentioned earlier, it is necessary to reduce the population density.

The maize stalk borer sometimes causes serious damages by eating 30 ~ 40% of the cobs. This insect can be controled by spraying 20% pyrethroids emulsion at the concentration of 3 mℓ per 1ℓ of water.

(4) Disease control for onion

As seen in both the 1989 and 1990 trials, onion is rarely attacked by diseases and insects, making it unnecessary to apply disease and pest control measures. However, in 1991, severe damages by White leaf spot (Phytuphthura purri Fuister) occurred. This disease occurs under high soil moisture and temperatures ranging betwen 15 ~ 20°C. The symptoms are the occurrences of blue white oil immersion like spots on the leaf blade causing in death and a change of color to white.

It is necessary to keep the field under well drained conditions. If symptoms come out, onion should not be cultivated on the same field in the following year.

The effective chemicals include, 500 ~ 600 times diluted powder of copper sulfate, 600 times diluted captan, and should be sprayed three times from the time of occurrence on every week.

(5) Control of the self-topping of cabbage caused by pest

No appriciable damage caused by disease was observed so far in Namushakende farms, but the problem is self-topping caused by the the cabbage webworm (Hellulle undalis fabricius), and aphids and spider mites attacking young seedlings.

The control of these insects requires the use of chemicals, like 1,000 times diluted PAP emulsion, 1,000 times diluted dipterex. These chemicals must be sprayed three times from the emergence of foliage leaf on every week.

(6) Insects control for tomato

Less damages occur in the dry season. But sometimes the spider mites appear under high temperatures and dry conditions. The spider mites are easily controled with acaricides or similar chemicals.

CHAPTER 3.

LAND CONSOLIDATION TECHNOLOGY FOR AGRICULTURAL PRODUCTION

CHAPTER 3. LAND CONSOLIDATION TECHNOLOGY FOR AGRICULTURAL PRODUCTION

3.1 Natural Conditions of the Zambezi Flood Plain Edge Area

3.1.1 Outline of the Target Area for the Land Consolidation Guideline

The natural conditions mentioned below, should be satisfied in order to implement a land consolidation system based on the double cropping of namely paddy rice and dry season upland crops in the Zambezi flood plain.

These are:

- enough water resources exist during the dry season
- inundated depth is relatively small
- gravity irrigation is possible from water resources to farm
- natural main slope is moderate (below 1/200)
- soil conditions are adequate for cultivation
- soil permeability is not high
- micro meteorological conditions are adequate for cultivation

The adequate area for agricultural development which can satisfy the natural conditions mentioned above is the Mataba seepage zone along the plain edge(refer to Figure 1.3.2). The Mataba seepage zone includes three soil types which are materialized by the Sishanjo, Mataba Sitapa, and Litongo zones. In the Mongu district, the Mataba seepage zone covers 45 km from north to south along the plain edge and 1.5 km maximum width.

If paddy rice is considered as the main target, the development potential of the Sisanjo and the Mataba Sitapa areas becomes the highest.

The followings are general characteristics relating to the Sishanjo and Mataba Sitapa areas.

(1) Sishanjo area

This area covers a shallow swampy zone of approximately 0.2-1.0 km wide along the edge of the flood plain. As this trough receives a steady lateral subsurface supply of seepage water from the sandy uplands, ground water levels in this area are high throughout the year. The soils of this area include very poorly drained,