SOIL PRODUCTIVITY RESEARCH PROGRAMME

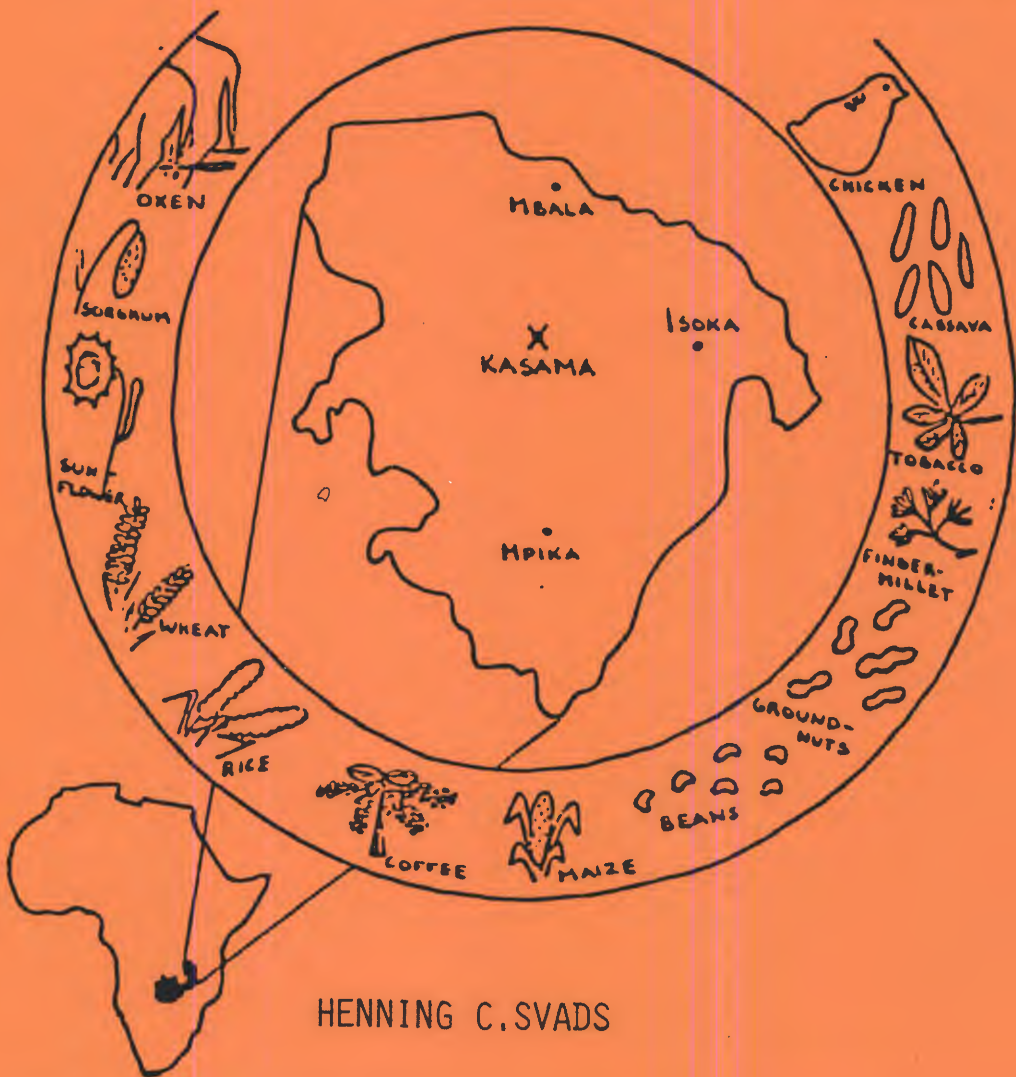
IN

THE HIGH RAINFALL AREAS IN ZAMBIA

REPORT ON PHASE I
1981-1983

PART 2

EVALUATION OF AGRICULTURAL CROPS AND CULTIVATION METHODS IN THE NORTHERN PROVINCE OF ZAMBIA



HENNING C.SVADS

NORWEGIAN CENTRE FOR INTERNATIONAL
AGRICULTURAL DEVELOPMENT
NORAGRIC
AGRICULTURAL UNIVERSITY OF NORWAY

SOIL PRODUCTIVITY RESEARCH PROGRAMME
in
THE HIGH RAINFALL AREAS IN ZAMBIA

Report on phase I, 1981-1983

Part 2

Evaluation of Agricultural Crops and Cultivation Methods in The Northern Province of Zambia

Henning C. Svads

Norwegian Centre for International
Agricultural Development
NORAGRIC
Agricultural University of Norway

CONTENTS

PUBLISHER's PREFACE

The Soil Productivity Research Programme (SPRP) in the high rainfall areas of Zambia commenced in April, 1981. The Programme was initiated on the basis of agreement between the Government of Zambia (GRZ), the Norwegian Agency for International Development (NORAD) and the Agricultural University of NORWAY (AUN).

The work is centered at Misamfu Regional Research Station, Kasama, and covers the Northern Luapula, Copperbelt and North-Western Provinces in Zambia, approx. 370 000 km^2. The main investigations have been carried out in Northern Province. The overall aim of the SPRP is to enable Zambian authorities to establish a long term soil productivity research programme which will produce more permanent farming systems in the high rainfall areas for farmers at different levels of technology.

The major target is the smallholders in the designated area.

For the initial period of the project (phase I) which ends June 30th 1983, AUN has provided senior scientific personell totalling 59 man months plus 21 man months representing graduate students. Staff assigned to SPRP by by GRZ has amounted to 2 junior technical officers. The project is expected to continue at an expanded scale.

The emphasis of the investigations in phase I has been to provide better understanding of soil conditions, crop production and farm management systems and their interactions. Information sources have been Department of Agriculture; Research, Land Use and Extension branches, Parastatal agencies, local farmers and relevant literature. In addition, the SPRP'soils, agronomy and agricultural economy sections have carried out field investigations in different parts of the high rainfall areas.

Reports and papers of general interest emerging from this project will be presented in this series.

We gratefully acknowledge the cooperation of the GRZ, especially the Research Branch of the Department of Agriculture. We also thank NORAD for its financial support of the SPRP project of which this publication is a part, and the NORAD representantion in Zambia for its logistical support and assistance. Finally, we thank the people of the Northern Province for their cooperation and hope this joint effort may serve their needs.

Halvor J. Kolshus
February 1986.

PREFACE

This report is related to the agro-technical part of SPRP with emphasis on traditional farming systems, crops and farming potential. The aim is to give a realistic description of the crop husbandry in the province, elucidate the problems facing the farmers, and to discuss strategies for cultivation which might decrease the fallow period and increase the level of crop production.

The report is to a large extent a collaborative product. Apart from myself being the Soil Productivity Research Programme Coordinator and the project leader for the agronomy section of the project, two other people have contributed in the process of field studies and elaboration of collected material, as well as the writing of report and thesis on which this final report is based.

> R. Haug, a graduate student in crop science from the Agricultural University of Norway (AUN) participated in the 1981 field study. Her thesis presented in 1981, was partly based on material collected during the field work, and partly based on secondary material.
>
> In 1982 S. Holden, a graduate student in vegetable crop science from AUN, made a second field study in Zambia. The material collected has been elaborated by him and published (Holden 1983). Parts of his thesis have also been used in this report.
>
> Both thesis have been useful contributions to this report and for further studies in the agronomy section of the Soil Productivity Research Programme.

Henning C. Svads
Agricultural University of Norway

1. INTRODUCTION

1.1 Background

For a long time different shifting cultivation systems have been practised by farmers in the high rainfall areas of Zambia. However, since the systems are geared to a low level of productivity and bound to become increasingly inadequate as the population continues to increase, there is a need to adopt more stable agricultural systems to replace the present ones.

1.2 Objectives

Before designing new agricultural systems, investigations and review of previous and existing farming systems is important. This is one of the objectives of the Soil Productivity Research Programme (SPRP) in Phase I.

2. SHIFTING CULTIVATION SYSTEMS

2.1 Definition

Shifting cultivation is the name we use for agricultural systems that involve an alternation between cropping for a few years on selected and cleared plots and a lengthy period when the soil is rested to restore its fertility. Cultivation consequently shifts within an area that is otherwise covered by natural vegetation.

2.2 Extention of the system

In a FAO Soils Bulletin No. 24, Shifting Cultivation and Soil Conservation in Africa, areas under shifting cultivation systems in Zambia has been estimated to 1,900.000 hectare while the total arable land and land under permanent crops are 4,800.000 hectare (Braun, 1974). These figures tell us that nearly 40 per cent of the land is under shifting cultivation systems.

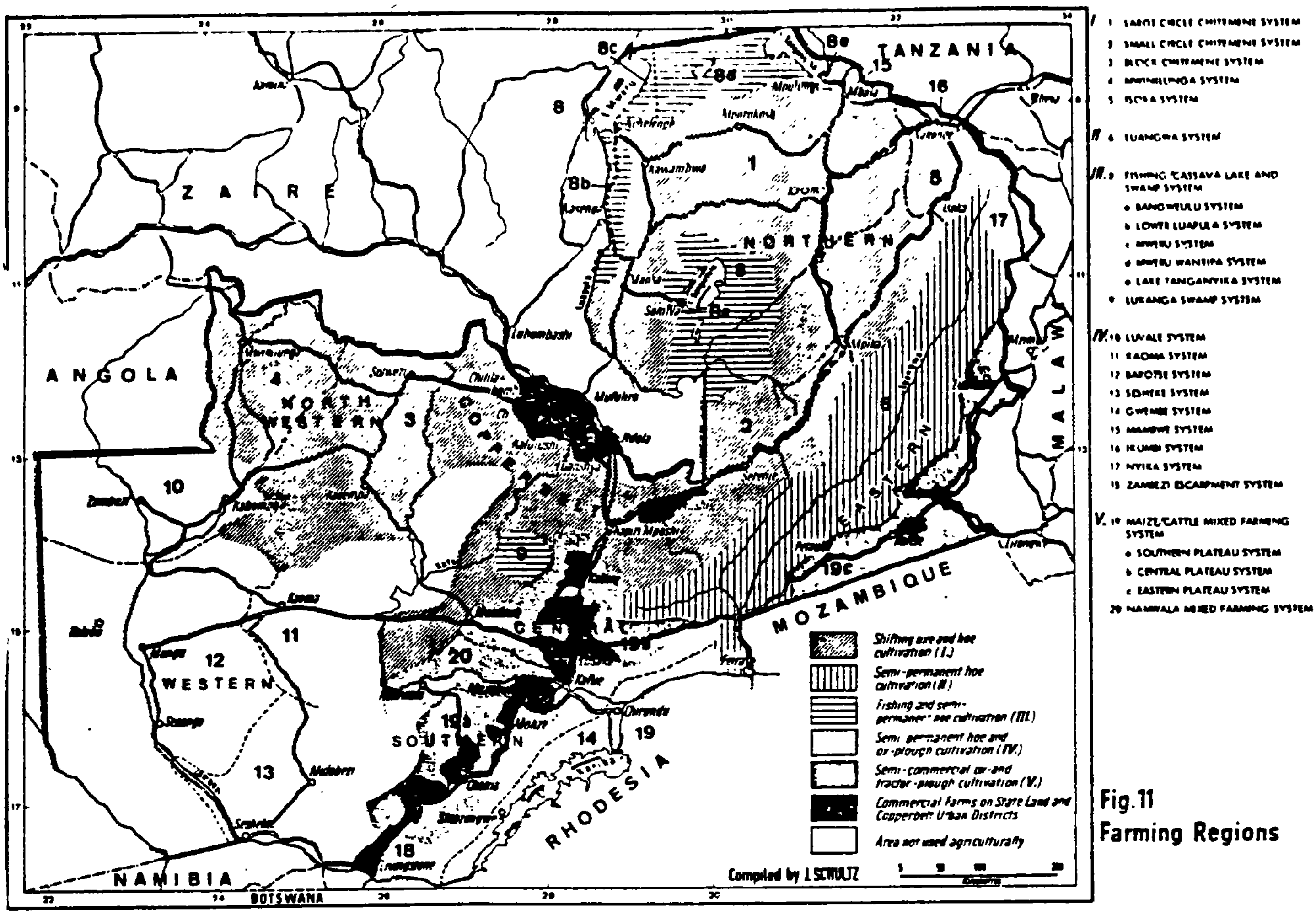


Fig. 1. Farming regions and shifting cultivating systems in Zambia. (Schultz 1976)

According to Mansfield et al. (1975) shifting cultivation systems are the dominating farming systems both in Northern and Luapula Provinces. Counts made over the Makasa and surrounding areas between 1932 - 1933 revealed:

a) Total hecterage 311,000
b) Number of gardens burnt 1,346
c) Number of hectare lopped to
provide wood for burn 5,470 ha
d) Average yield of finger millet
1,680 kg/ha.
(Boyd, 1959)

It was further estimated that 1.8 per cent of the land was being cut annually and taking 15 years as a minimum requirement for tree regeneration, 30 per cent of the woodland was out of production at any one time. Further estimates state that 40 per cent of the land was not suitable for Chitemene and only 30 per cent remained for cultivation. These figures have drastically changed with increases in population (Mansfield 1973).

2.3 The Chitemene system

This method of cultivation which includes the use of natural forest or woodland as the agricultural fallow crop has been well described by Trapnell (1953). Five shifting cultivation systems can be distinguished. Two differ substantially from the chitemene systems, either by the predominance of a semi-permanent hoe cultivation (Mwinilunga system), or by the raising of cattle (Isoka system).

1 - Large Circle Chitemene (LCC)
2 - Small Circle Chitemene (SCC)
3 - Block Chitemene (BC)
4 - Mwinilunga system
5 - Isoka system

The classifying is done by considering the following characteristics:

a) ratio between cleared and cultivated land
b) shape and size of cleared and cultivated area

c) ratio between crop growing and fallow period
d) crop sequence
e) staple crop
(Schultz 1976).

The three chitemene systems have been named according to the field-shape which characterises each system. Ratio of cleared area to field is approximately 1/10 - 1/20 in SCC, 1/5 - 1/10 in LCC and still less in BC. Continuous cultivation of a given field seldom exceeds three years in the SCC and BC, and may reach 5 - 6 years at the most in LCC. The fallow period depends on the time required for aboral regrowth, which is shorter in the clearings of LCC where traditionally only the branches are lopped. The principal crops, both in terms of frequency and acreage are cassava, maize and finger millet.

2.3.1 Large circle chitemene

This system is distributed over the greater part of northwestern Zambia. Large circle chitemene constitutes the agriculture of the Bemba.

Cultivation technique

The cultivation starts with the selection of a field site, important in that connection is quantity of available wood material for burning and botanic composition of the ground. Clearing and preparation of a selected area starts in May - June or some times later. The cutting is exclusively a male activity, some climb the trees, chopping off the branches and leaving the trunks standing in the field, others cut the whole tree at shoulder hight. This seems to be increasingly common, because it is labour saving and less dangerous. When the trees and branches have been cut, the women have to collect and pile them in a special way, thus preparing the field for burning. The hight of the heap could be about 1-1 1/2 m, but may also be determined by the type of soils prevailing as it is believed that heat enters a light soil much more easily than a heavy one; hence a greater heap is laid on heavier soils than on light ones (Boyd 1959).

The stacked up area can be of any size depending on the availability of loppings and how easily they can be carried. This was illustrated by Peters (1950) in Serenje, showing the burnt areas as a percentage of total area cut and number of years regeneration before cutting.

Table 1. Burnt area as a percentage of total cut, Serenje District (Peters 1950)

No. of years regeneration before cutting	9-12	13-16	17-20	< 20
Burnt area as a percentage of total cut	4.4%	6.25%	7.31%	9.75%
Ratio of burnt area to cut woodland	1.23	1.16	1.14	1.10

The stack of cuttings are burnt prior to the beginning of the first rains which normally is by the end of October. The first crop is usually finger millet, Eleusine coracana, and the seeds are sown in the ash patch towards the end of December. Where cassava is popular, it comes first by planting cuttings obtained from older branches.

After the initial millet crop, the cropping sequence is largely of personal choice and are not confined to any one locality (Trapnell 1953). The most common, however, are:

a) Millet - Groundnuts - Beans - Millet
b) Millet - Groundnuts - Millet - Beans
c) Millet - Millet - Beans - Millet
d) Millet - Sorghum - Beans - Millet

See also Table 27, Different rotation systems in Chitemene cultivation.

Where cassava was planted, they would continue harvesting it bit by bit after two years until exhausted and the field will be abandoned for a long fallow period which may last up to 20 years (Mansfield 1973).

According to Schultz (1976), cassava is grown by 87 per cent of the households in the Large Circle Chitemene system and can be found on 33 per cent of their land. Maize is grown by 74 per cent while finger millet is grown by 65 per cent of the households (Table 2). These findings do not correspond well with the traditional cropping sequence where finger millet is planted as the first crop in the system. The figures may indicate that changes in cropping and production patterns is taking place. This is clearly demonstrated in some areas in Serenje and Mpika districts by IRDP Mpika (IRDP 1983). See item 6.

Table 2. Large Circle Chitemene, area and ratio of crops (Schultz 1976)

163 samples	Maize	Finger-millet	Cassava	Ground-nuts	Beans	Mean area
Mean area of crops per farm household (ha)	0.56	0.32	0.72	0.20	0.20	2.16
Mean area of crops per those farm households only which grow the crops (ha)	0.72	0.52	0.84	0.36	0.40	
Percentage of farms which grow the crop	74	65	87	60	57	

Each household cuts a new chitemene every year, and have 4 - 6 plots at the same time, approximately 2.0-2.45 hectares all together.

Carrying capasity

The Chitemene systems have different carrying capacities and hence different critical population densities for their survival. In assessing carrying capacity from sustained cut-and-burn chitemene culture Mansfield et al. (1975) considered four factors as important:

a) The period required for adequate regeneration for the woodland.
b) The ratio of ash circle garden to cut woodland required for that garden and the size of the ash garden itself.
c) The proportion of the whole area which has woodland growth suitable for chitemene.
d) The area of additional gardens used by the people to supplement the ash garden when these directly compete for woodland.

The period required for regeneration will naturally depend on the vigour of woodland growth which in turn depends on the type of woodland, soil and climate conditions found locally plus the degree of protection from late fires. Trapnell (1953) for his overall estimates used 20 years as regeneration period. Allan (1967) gained the impression that in areas more favourable to tree growth than the Serenje plateau where Peters used a 35 years regeneration period, shorter periods than that required for full regeneration were sufficient to sustain Chitemene of the order of 22 - 35 years. Mansfield et al. (1975) is using 20 - 30 years as regeneration period. Investigations done by SPRP in Hwenesanso village indicate a shorter fallow period, 5-10 years (Haug 1981).

The reason for this maybe a shortage of forest. Traditionally, the Large Circle Chitemene system has a shorter fallow period than the other types of Chitemene. This is because they only cut the top branches and leave the rest of the trees intact. By doing so a much quicker regrowth appears. In the past, however, one has started to cut down the whole trees.

The area cut is about 6.5 - 10 times the cultivated field (Trapnell 1953). Lack of suitable woodland leads to clearing of bigger areas and hence reduction of the fallow period, which both contribute to making the degeneration of the forest more serious as time passes.

Approximately 1.0 ha of land per person is cleared annually for Chitemene. Totally an area of 40 ha per person is necessary when

60 per cent of the land is suitable for Chitemene (Mansfield et al. 1975 and Allen 1967). For a household of 7-8 persons they require approximately 300 ha.

Table 3. Area per person and critical population densities in Large Circle Chitemene (Mansfield et al. 1975)

	Total area with suitable land for Chitemene			
	100%	75%	60%	50%
Weighted area required per head of LCC		33.6 ha	42.1 ha	50.6 ha
Average critical population densities, in number of persons per unit areas persons/km^2	3.9	3.0	2.4	2.0

Critical population densities in Chitemene areas is estimated to 2 - 4 persons/km^2 depending how much of the land is suitable for Chitemene cultivation (Mansfield et al. 1975 and Allan 1967). In Northern Province the population density at present varies between 1 - 4 persons/km^2. In some areas the population density is 4 -10 persons/km^2 or more.

2.4 The area movud system

The Grass movud system is practised east of Mbala and along the border with Tanzania. The system has possibly been developed from Large Circle Chitemene after the woodland was destroyed. But it is also possible that its origin can be found in treeless areas in Tanzania.

The system is characterized by:

a) grass being buried in mounds in order to rot down in a natural composting process;
b) cattlekeeping;
c) the population density being higher than in the chitemene areas.

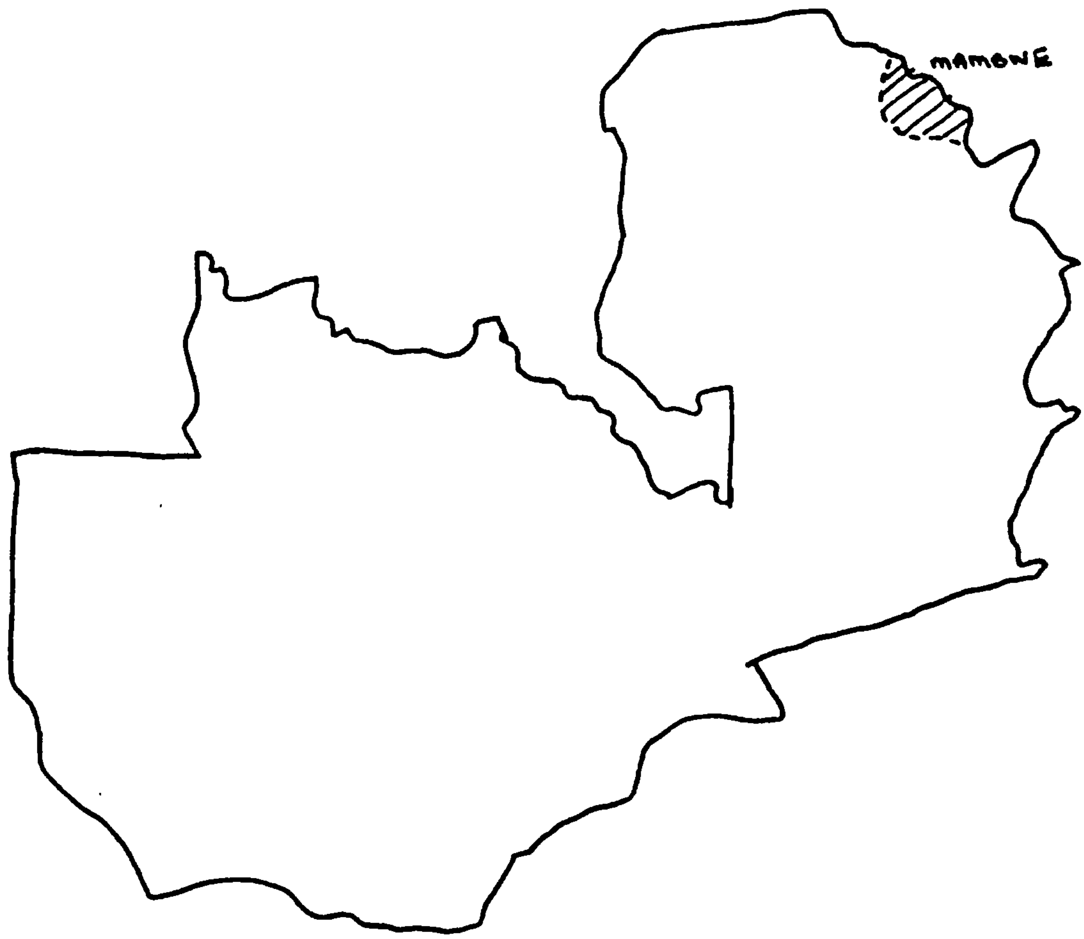


Fig. 2. Mambwe tribe (Davies, Agwell 1972)

Cultivation technique

The cultivation follows a rotation system with regular changes of crops, succeeded by fallow periods. The cycle of a new piece of land begins late in the rainy season (March). First the ground is hoed and formed into small mounds, under which the grass is buried to let it rot down in a natural composting process. The mounds are up to 1.8 - 2.4 m in diameter. Beans may be planted on the mounds immediately, and they become ripe before the end of the rainy season. The last-made mounds are often left bare.

When the next rainy season begins (second year), the mounds are levelled and the compost-like mixture is spread out evenly on the field. At the same time, the weeds in the soil are worked into the compost mixture. Previously finger millet and sorghum were planted in these relatively fertile fields, but at present pure maize or pure finger millet stands are usually planted (Schultz 1976).

In the third year mounds are usually rebuilt and finger millet, groundnuts, beans and/or maize are the most important crops planted. Finger millet has been the most common crop, but maize has gradually taken over, often mixed with beans and/or groundnuts (Allan 1967). These mounds are not levelled again until the beginning of the fourth year, when maize or finger millet is grown. There might be another harvest of cereals in the fifth year, after which the field is left fallow for 4 - 10 years.

There are few data on length of cropping and fallow for this system. Usually the cropping period is 4-5 years (Mansfield et al. 1975). According to Allan (1965) the minimum fallow period on the most fertile soil should be 8 years. Investigations done by SPRP (Haug 1981) indicate a fallow period of only 5 years. The same result was obtained by Schultz (1976). Mansfield (1973) and Boyd (1959) believe in a resting period of 15-20 years. Trapnell (1953) says that the land is considered ready for recultivation when the weedgrass from former cultivation has disappeared and the Pumpu grass, *Hyparrhenia filipendula*, has become dominant. It seems possible that it is the large increase in weed growth rather than soil exhaustion which ends the cultivation of a piece of land (Schultz 1976). For rotational programme, see also Table 28, Different rotation systems in the Mambwe area.

A new site is cleared every year and covers about 0.4 - 0.6 ha (Trapnell 1953). Schultz (1976) claims that each site constitutes about 0.1 - 0.2 ha and that the total area under cultivation per holding is 0.5 ha. This is the smallest average for all the farming regions in Zambia. Observations done by SPRP indicates that the total cropped area per holding is somewhat higher than the figure given by Schultz (1976), but it is difficult to estimate average size with any degree of accuracy. In this grassland cultivation, the distinction between main fields and village gardens has virtually ceased to exist (Trapnell 1953).

Crops and livestock

The following sequence of crops is drawn up both according to cultivation frequency, and according to acreage:

maize	100%
beans	92%
groundnuts	77%
finger millets	69%
cassava	62%

(Schultz 1976)

It is assumed that about 70% of the households use fertilizers when growing maize. The traditional crops are usually not fertilized (IRDP 1981). Weed infestation is a major problem in the system.

The Mambwe people have a long tradition in keeping cattle. For this reason labour does not seem to be as much of a limiting factor as it is among the chitemene households. About 60% of the farmers use oxen for ploughing at least some of their fields. The non-owners may hire or borrow oxen from relatives, neighbours etc. (IRDP 1981).

Cattle manure is seldom used to improve the soil except in village gardens (Schultz 1976).

The Mambwe farmers usually practise winterploughing in March if new fallowed is going to be cropped. The ploughing is repeated in November, followed by harrowing. If the cultivation takes place on old land the field is ploughed once or twice in November/December (Stølen 1981).

Carrying capacity

As has been mentioned before the critical population density in the Large Circle Chitemene system is 2-4 persons/km^2. The figures in Table 4 show that the critical population density in the Grass mound system is much higher, approximately 2--40 persons/km^2 (Mansfield et al. 1975). Allan (1967) has estimated the critical population density to 12 - 27 persons/km^2. The need for land is approximately 2.5-4.5 ha. In the Large Circle Chitemene system the figures are more than 40 ha per person. However, the figures depend on the length of the growing and resting period.

Table 4. Area per person and critical population density in the Grass mound system (Mansfield et al. 1975)

	Total area suitable land for Grass mound system					
	10%	75%	60%	50%	40%	30%
Weighted area required per head (ha)		2.4	3.0	3.6	4.3	5.1
Average critical population densities in number of persons per unit (persons/km^2)	56	42	34	28	19	17

2.5 Investigations into shifting cultivation systems

Trials on traditional systems started at Lunzuwa Agricultural Station in Mbala in 1928. Results from experiments that have been performed at Lunzuwa for 1928-1958 are presented in Chapter II, item 5.1. Here is presented a summary of the findings.

Effects of Chitemene burning on the soil

Visible effects of the chitemene technique are:

a) the ash layer forms an exellent seed bed
b) hardly any weed growth of importance
c) mineral nutritients provided by the ash which increases the content of phosphorus, potassium and calcium in the soil
d) the physical proporties of the soil are improved due to the increase in calcium
e) the soil acidity ratio is changed as bases are supplied, resulting in increased pH (Allan 1967).

Comparing the Grass mound system with Large circle chitemene

Mansfield (1973) concludes that if there is sufficient woodland available for chitemene cutting, the Mambwe system will be less attractive for small farmers, taken into account labour requirements and length of cropping period.

Experiments show that yields from chitemene were superior to those from the Grass mound system, involving beans and groundnuts. "Pops" did not occur when groundnuts were cultivated in chitemene plots.

The Grass mound system compared with chitemene; summary

a) The cropping period in both systems is limited to 4 - 7 years.
b) It is necessary to have a relatively long fallow period in both systems.
c) Weed infestation is more severe in the Grass mound system than in the chitemene. This may lead to earlier abandonment of the cropped land in the Grass mouned system.
d) Composting may increase the yield in the short term, but the positive cumulative effects are small.

(Mansfield 1973)

3. THE VILLAGE GARDENS

In addition to the chitemene fields, every household owns village gardens near their house, where they grow subsidary crops. All land inside and immediately around the village is claimed by individual owners. The claims are even uphold when use of the area is temporarily discontinued or when the village itself is abandoned (Richards 1961, Schultz 1976).

Cultivation technique

The grass turf in the village gardens is cut out with hoes and heaped upside down in small mounds. The layer of earth covering the grass accelerates the rotting process and compost forms quickly. This compost is further utilized when the mounds are flattened later in the rotation cycle. In addition to the compost, manure made of various kinds of refuse may be applied (Schultz 1976). The village gardens are used more or less permanently as a result of the higher intensity of husbandry applied to them.

It is common practice to plant early crops of e.g. millet and beans in the village gardens. This is done to improve the food situation in the period March/April to May/June, the so-called hunger months (Richards 1961, Allan 1967).

Crops grown

The crops grown in the village garden may be divided into four different groups:

1. Farm crops (latin in brackets)
   Finger millet (*Eleusine caracana*)
   Bulrush millet (*Peunisetum typhoides*)
   Groundnuts (*Arachis hypogea*)
   Beans (*Phasetus vulgaris*)
   Cassava (*Manihot esculenta*)
   Maize (*Zea mays*)

2. Vegetables
   Pumpkins (*Cucurbit spp.*)
   Sweet potatoes I(*mpmea batatus*)
   Rape (*Brassica napus*)
   Tomatoes (*Solanum lycopersicum*)
   Okra (*Hibiscus esculentus*)
   Cabbage (*Brassica oleracea*)
   Onions (*Allium kepa*)
   Carrot (*Daucus carota*)
   Peas (*Pisum sativum*)

3. Fruits

   Bananas (Musa spp.)
   – Mango (Mangitera indica)
   Guava (Pisidium guajava)
   Citrus (Citrus spp.)
   Pawpaw (Carica papaya)
   Avocado (Persea spp.)

4. Crops cultivated for other purposes than food consumption

   Tobacco (Nicotiana tabaccum)
   Sugercane (Saccharum spp.)
   Chillies (Capsicum frutescens)

The household usually grow one or more crops from each of these four groups. The most commonly grown crops are cassava, sweet potatoes, pumpkins, beans, bananas and tobacco.

Richards (1967) claims that the Bemba people have little tradition in growing vegetables and cultivate a modest quantity of fruit and vegetables. As the villages have become more permanent, the possibilities for growing fruit have increased. In addition to bananas, mangotrees are quite common, and guava and orangetrees seem to be making progress. At present, the potential is limited for fruit and vegetable marketing. Apart from production for self-consumption and a restricted local market, the possibilities for selling the product are small. Households situated near towns have greater opportunities for selling the product, but lack of control over market forces leads to periodic overproduction and lowered prices giving rise to insecure returns.

Trapnell (1953) states that the Bemba and Lungu grow roots, pulses and maize on mounds in their gardens. The mounds are made by hoeing up and piling the grass sods and throwing a layer of earth over (grass compost). Brushwood may be made into small stacks for burning and these sites are used for minor crops or millet. Sweet potatoes, cassava, maize, finger millet, small cowpeas, pumpkins, gourds, beans and some places groundnuts (near Kasama) are found in these gardens.

4. RIVER- AND DAMBO GARDENS

In addition to village gardens and chitemene fields some households have a river- or dambo-garden, if such areas are found near the village, where they grow vegetables, maize etc. during the dry season.

The Nkule "gardens" of the Iwa is a method utilizing quite variable dambo soils for finger millet (Trapnell 1953). The garden is prepared in short grass of grey dambo soils by hoeing over an area of about three quarters of an acre in August-September. The sods are turned up and piled in heaps and burnt in October-November. A trench is dug around the garden. Maize and beans are planted during the first rains in November. Pumpkins, gourds, cucumbers, cowpeas, pigeon peas and Dolichos beans are also included.

The Fisebe gardens of the Wisa are also mentioned as being of great value as sources of food in the mid rains before the small maize harvest of the ordinary gardens and offer much scope for the increased production of vegetables. Maize, beans and minor crops are grown in these gardens. Another advantage of cultivation in the dry season is that the crops are less damaged by pests and diseases.

Trapnell (1953) mentions that dambo-gardens are not normally seen, and that there are only some enterprising individuals who have started such cultivation. Today, river- and dambo-gardens seem to be more widespread and common both for home consumption and for sale.

5. SUMMARY OF PREVIOUS INVESTIGATIONS PERTAINING TO A MORE SETTLED SYSTEM OF AGRICULTURE

Early attempts to formulate a system of more permanent cultivation involved the application of manure. Attempts to investigate permanent agriculture as such was done locally and no attempt was made to replicate this work on soil types prevelent in the Province. Work done on this, however, enabled investigators to conclude that liberal manuring and spirited weeding with frequent fallows may make permanent cultivation possible (Boyd 1959).

Before investigations were abandoned, it was found that:

a) Both common systems Grass mound and Chitemene as practiced by the local people have a limited life of between 5 - 7 years. Under continuous cereal this life span is reduced.

b) If manures are used, yields are higher but field become so infested with weeds that they are abandoned earlier.

c) Use of non cereal crops between successive cereal break makes for longer life.

d) No matter what alternative crop is used beans, groundnuts, sweet potatoes or cassava none could halt the decline of successive millet yields.

e) Use of compost/manure markedly benefits the crop to which it is applied but has no residual value. However, over the long term, it could reduce the rate of decline that is in production, it increases the length of life of a garden, the biggest problem being weeds.

(Boyd 1959).

6. CHANGES IN CROPPING AND PRODUCTION PATTERNS IN NORTHERN PROVINCE

Farm systems

The traditional farming systems of the upland areas have centred on Chitemene cultivation - large circle Chitemene and small circle Chitemene. Over the past 2 to 3 decades there has been a rapid change away from Chitemene to more settled semi-permanent farm systems including maize. This is clearly demonstrated from ongoing investigations in Serenje, Mpika and Chinsali districts conducted by IRDP, Mpika (1983). For the same reason see also item 6, Tables 2, 8, 9.

IRDP monitoring and evaluation survey

As one of its requirements IRDP Serenje-Mpika-Chinsali established a monitoring and evaluation unit in 1981 to collect and analyse farm and household data from areas throughout the 3 districts. Six sample areas were chosen, two in each district. Each sample comprises 45 farmers selected at random following an initial household census. There is thus a total of 270 farmers in the survey. Every year the household composition, crop areas and production of each farm are measured. It has also been possible to abstract data backwards from the start of the survey for maize sales.

Main Crops

In the sample areas the major crops grown include maize, finger millet, cassava, beans, groundnuts and sunflower. Table 5 shows the areas and proportion of each crop grown on the sample farms during the first two years of the survey 1980/81 and 1981/82. The figures are derived from only three of the six sample areas. In each case the least progressive sample area in each district has been chosen.

Table 5. Main crop areas and proportions by farm for three sample areas during 1980/81 and 1981/82 crop seasons (135 farmers). (IRDP, Mpika 1983)

Sample area	CROP: Maize				Finger millet				Cassava				Other				Total			
	1980/81		1981/82		1980/81		1981/82		1980/81		1981/82		1980/81		1981/82		1980/81		1981/82	
	Av. Ha	%	Av. Ha	%	Av. Ha	%	Av. Ha	%	Av. Ha	%	Av. Ha	%	Av. Ha	%	Av. Ha	%	Av. Ha	%	Av. Ha	%
Chibale S (Serenje)	1.71	51	2.15	58	0.99	29	0.71	19	0.26	8	0.17	5	0.40	12	0.67	18	3.36		3.70	
Mpumba W (Mpika)	1.16	56	1.39	60	0.50	24	0.54	23	0.16	8	0.13	5	0.27	12	0.26	11	2.09		2.32	
Mubanga N. (Chinsali)	1.13	43	1.29	45	0.23	9	0.31	11	1.06	40	1.02	26	0.20	8	0.20	7	2.62		2.82	
All areas	1.32	50	1.59	54	0.57	21	0.52	18	0.48	18	0.42	15	0.28	11	0.38	13	2.65		2.91	

From the table it can be seen that between 85 and 90% of the total arable area is comprised of the three crops; maize, finger millet and cassava. In Serenje and Mpika maize constitutes about 55 to 60% of the farm area, finger millet 20-25% and cassava 5-8%. In Northern Chinsali, however, 36-40% of the farm area is under cassava with correspondingly less maize and finger millet. This reflects the diet of the area which is wholly based on cassava with maize solid as a cash crop.

Average farm areas range from around 3.5 ha in the Serenje sample, the most progressive of the three areas, to just over 2 ha in the Mpika sample which is the least progressive. "Other Crops" include beans and groundnuts which are more frequently grown in Mpika and Serenje.

Most of the finger millet is grown for beer brewing. In Chinsali and Serenje a large proportion of the finger millet area consists of Chitemene gardens whereas in Mpika the finger millet is mainly grown on the "ibala" (main farm) fields. Even in those areas continuing to practice the Chitemene system, the nature of the system has changes in that cassava and groundnuts are no longer grown as the second year crops following finger millet and instead have been incorporated into the "ibala" fields.

Changes in cropped areas (1980/81 to 1981/82)

Although the time period of one season is too short to draw any firm conclusions, some interesting trends are observable with regard to changes in farm and crop areas. The total farm area in all the sample areas rose by approximately 10%. In Chibale there was a marked increase in maize (+26%) at the expense of both finger millet (-28%) and cassava (-35%). In Mpumba, however, the increase in maize was at the expense of cassava (-20%) and not finger millet, which rose by 8%. In Mubanga the main food crop cassava was maintained (-4%) and the areas of maize (+14%) and finger millet (+35%) both rose.

The importance of maize

Of all the crops grown in the sample areas maize is becoming increasingly dominant (ref. Table 5). Since it is Zambia's staple food especially for the urban populations, it has received far more attention and support from Government authorities than any other crop. Not only is it the staple of the urban population but it is now displacing the traditional staples - millet and cassava in many parts of the three districts. As can be seen from tables 7 and 8, maize has become the dominant crop in the province and districts, except Chilubi were puddy rice exceed maize.

In the Chinsali sample areas of Mubanga maize is grown largely as a cash crop with very little being eaten whereas in Mpumba (Mpika) and Chibale (Serenje) it is both a cash crop and the major food crop. As economic pressures grow, more and more of the urban populations of the boma towns are supplementing both their income and food supply by growing small plots of maize.

It would appear that the change from Chitemene to semi-permanent agriculture is accompanied by a consistent increase in the maize area. It is of course accepted that such a system is far from perfect and may ignore many less obvious changes within the farming system.

District level maize production

The dynamics of maize production described have not only occurred in the sample areas but over the three districts as a whole. Table 6 illustrate the increase in sales over the past decade in Serenje, Mpika and Chinsali Districts.

Table 6. District Level maize sales 1970-1982 Serenje, Mpika and Chinsali Districts (IRDP, Mpika 1983

	'OOC Bags solid in the year:												
District	1970	'71	'72	'73	'74	'75	'76	'77	'78	'79	'80	'81	'82
Serenje	0.6	4.5	13.4	27.0	21.7	34.0	42.4	42.9	59.9	35.6	52.6	76.0	65.0
Mpika	-	6.9	10.0	6.5	3.3	13.3	14.6	18.0	23.6	11.2	16.4	30.0	38.3
Chinsali	-	6.0	6.3	3.0	4.7	8.2	15.9	18.6	20.3	10.3	15.2	37.5	67.0

The figures illustrate a dramatic take-off in production in Serenje around 1973, whereas in Mpika and Chinsali this did not occur until 1981. It is considered that the point and extent of this maize production take-off is closely related to a favourable maize price and the adequate provision of extension and input/marketing services. See also Table 7 for maize production in other districts.

The effect of services

Much speculation has arisen as to the explanation for the rapid changes in both farm systems and maize production in the three districts and Northern Province as a whole particularly in the last two years. Undoubtedly climatic conditions have been generally favourable but this has always been the case. Most evidence suggests that the increase results from decisions by individual farmers to either grow maize for sale for the first time or to increase their maize area in order to increase sales. The increase in the producer price of maize is thought to have given a major impetus to this decision-making process (IRDP, Mpika 1983). However, this cannot explain marked differences between different areas within the three districts and between the districts themselves.

The differences are illustrated in Table 6. The two districts in Northern Province show a very similar slow increase until 1982, which is very different from the much faster increase in Serenje district (Central Province). This is most probably attributable to the higher quality of service provided by NAMBOARD to farmers over this period in contrast to those provided by NCU (IRDP, Mpika 1983).

An interesting divergence between Mpika and Chinsali occurred in 1982 (which seems likely to be even more marked in 1983). The very rapid increase in Chinsali is attributed to the much improved workings of the Department of Agriculture and NCU, which has not occurred in Mpika to the same extent (IRDP, Mpika 1983).

Effects of farm size on total maize production

Another major factor governing the rate of increase in maize or total crop production from a given area is the distribution of farmers in the different farmer categories. One of the main features from the IRDP investigation is that in terms of absolute area the amount of finger millet and cassava remain relatively constant regardless of farmer category whereas the area of maize increases dramatically as one moves to the larger farm categories. These trends confirm the concept of subsistence farmers selling a maize surplus as they expand their area. It should be emphasised that as the proportion of farmers in the higher categories in an area increases the potential of that area to show marked increases in production decreases.

This is attributable to the planting season labour constraint. To overcome this constraint a new level of technology is required, for example the introduction of work oxen. Experience of the very high demand for work oxen in the three districts and the enthusiastic response to the introduction of an ox-package supports this.

Implications for future policy

The IRDP, Mpika report presents a picture of very dynamic change in the three districts, Serenje, Mpika, Chinsali, with small scale farmers rapidly increasing their area and sales of maize, in area often considered unsuitable for maize.

According to IRDP there are two potential barriers to further movement; firstly the erratic quality of services provided (inputs, credit, marketing and extension) and secondly a technology barrier as farmers reach maize sales of about 60 bags and a farm size of four to five hectares.

The figures indicate that rapid increase in maize production and sales is taking place and suggest that to achieve government policy of further increasing maize production, services must be improved at both district and depot level. One of the main constraints on access to inputs is credit. Consequently farmer categories and a farming improvement have been derived based on approiate sources of credit at each stage starting with the cooperative credit scheme and progressing to AFC and commercial banks.

It would seem that the lima approach towards the small scale farmer, involving a simple extension message, the use of purchased inputs, and an attractive producer price are together encouraging movement up the farming ladder in these northern districts with no maize tradition and are proving capable of producing a very significant rise in crop production. Any system of settled farming in these areas depends on external inputs and it needs to be recognised that the small scale producer has become very dependant on these to maintain his income. Any major failure to provide and coordinate supply services at either district or depot/village level will have very significant implications for production from the area; which has now developed a farm system based on subsistence requirements plus the sale of a cash crop, maize.

The IRDP suggest that the tecnology barrier associated with the planting season labour bottlenecks can be overcome by using oxen and it is hoped to follow the progress of farmers who aquire oxen in the three districts to determine their next constraint.

Finally the IRDP report state that the increased incidence of maize and continuous arable cropping will require the development of settled farming systems for two reasons:

1. First to maintain the viability of infrastructural investments. The provision of services - proven to be so important in previous sections - will break-down in the event for dispersion of the cultivated area and reduction of turnover at established depots.

2. Secondly to avoid a possibly irreversible breakdown in soil physical and chemical fertility. Such settled farming systems should include diversification of the cropping pattern to include a wider range of cash crops (each requiring an attractive producer price), crop rotation, use of lime and the inclusion of livestock.

The lima programme whilst appropriate in these areas in the initial stages of settled farming, (i.e. "subsistence plus") will in the long term need to be developed from its present single crop approach into a whole farm approach.

7. FARM CROPS IN THE NORTHERN PROVINCE

In the following, the farm crops grown in the Northern province are described with respect to their importance, spreading, plant characteristics, ecology, recommendation for cultivation, labour consumption, growing potensial and research work. Rotation systems and mixed cropping are also included.

In fig. 3 is presented the distribution of main staple crops grown in Northern Province of Zambia.

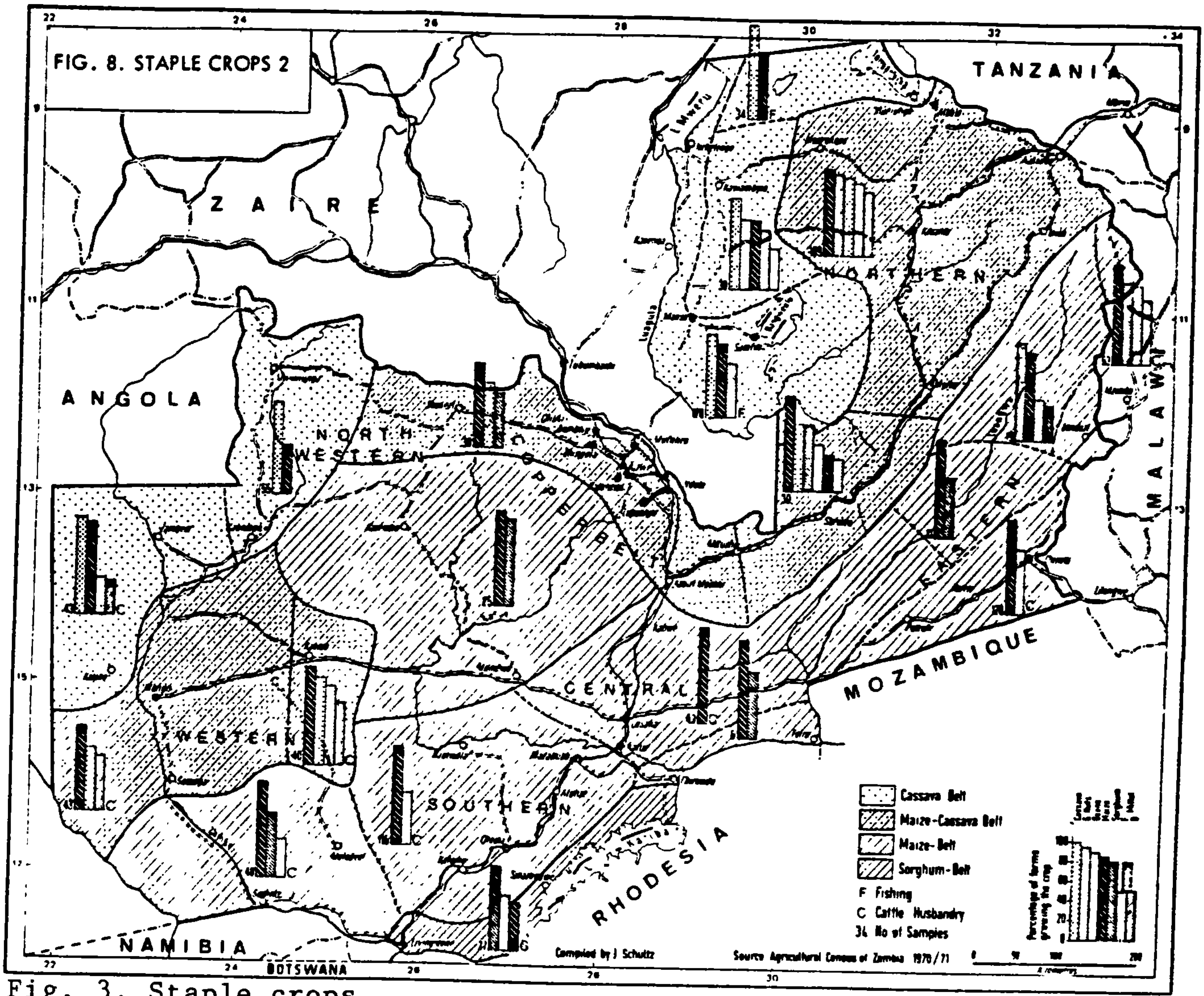


Fig. 3. Staple crops
in the Northern part
of Zambia (Schultz 1976)

7.1 Production of farm crops in Northern Province

Table 7 comprises intake of different crops by official marketing organisations in Northern Province during the period 1976-1983 (CSO Annual Agricultural Statistical Bulletin 1983, Lusaka 1984).

Table 7. Intake by official marketing organisations. Northern Province 1976-1983

Crops/year	1976	1977	1978	1979	1980	1981	1982	1983
Maize (90 kg bag)	183.607	212.364	203.034	120.763	159.226	328.273	648.590	653.035
Sunflower (50 kg bag)	1.424	1.855	1.763	1.431	1.348	1.790	3.238	3.051
Soyabeans (90 kg bag)	10	133	26	21	40	30	51	27
Groundnuts (90 kg bag)	55	102	9	32	124	18	18	36
Paddy rice (80 kg bag)	8.919	9.593	12.932	5.659	11.296	16.753	20.349	36.438
Wheat (90 kg bag)	-	164	858	76	5.396	6.560	2.083	-
Seed cotton (kg)	6.042	1.172	3.935	8.955	7.530	29.807	10.371	17.398
Tobacco (kg)	-	-	-	12.506	29.924	11.324	661	7.169
Coffee (clean kg)	36.942	49.618	77.359	32.903	27.104	40.398	73.080	83.931

Table 8. Final crop forecasting 1984/85 season. Northern Province (Dept. of Agriculture. Kasama).
The average yield figures in kg per hectare are estimated by Svads

	Maize	Sun-flower	Soya-beans	Ground-nuts	Rice	Wheat	Beans	Sorghum	Cotton	Tobacco	Finger millet	Coffee
No. of farmers	60.710	309	1.020	4.316	4.637	8	6.047	203	119	17	9.465	507
Hectares	48.737	409	621	2.663	4.977	210	4.915	83	73	10	7.682	550
Total production	1.073.771	4.224	5.173	21.272	92.074	8.014	45.497	965	35.520	8.000	91.799	197.884
Marketable surphes	884.447	3.945	5.087	185	53.825	110	610	20	35.520	8.000	945	196.764
Average yield	1.983	516	750	719	1.480	3.434	833	930	486	800	1.075	360

Maize has for many years been the most important cash crop in the province. But from 1981 onwards the production and thus the intake by official marketing organisations has increased tremendously. In its maize forecast production for 1984/85 season the Department of Agriculture has estimated the total production to more than 1 mill. bags produced by 60.000 farmers on 48.737 hectares of land. A very high proportion of the maize production is sold. This is demonstrated by the figures in Table 8.

The maize production is to a great extent in the three districts of Isoka, Mbala and Kasama. Other districts like Chinsali, Mpika, Luwingo and Mporokoso are also contributing with a good proportion of maize while the production in Kaputa and Chilubi is of minor importance to the total maize production and intake by official market organisation in Northern Province. See Table 9.

Table 9. Final crop purchases 1983/84 season, Northern Co-operative Union LTD

	Maize (90 kg)	P/Rice (80 kg)	S/flower (50 kg)	Beans (90kg)	F/millet 90 kg)	Wheat (90kg)	S/beans (90 kg)	Sorghum (80 kg)	G/nuts (90kg)
Kasama	134.653	31.852	528	11	8	-	15	9	-
Mbala	190.847	771	147	9	105	62	1	1	-
Isoka	271.241	431	234	130	2	-	1	2	-
Chinsali	81.650	2.158	194	3	3	-	-	2	-
Mpika	61.994	61	1.701	1	-	-	13	-	-
Luwinga	32.677	935	97	266	41	1	3	-	1
Mporokoso	12.322	481	131	98	16	-	-	-	-
Kaputa	1.515	84	78	-	-	-	-	-	-
Chilubi	363	5.336	22	-	-	-	2	-	-
Total	787.262	42.029	3.132	518	175	63	35	12	1

Paddy rice is an other crop which has had a similar positive production development as explained for maize. As can be seen from Table 7 the production from 1980 onwards has increased quite a lot from one year to another. The forecast production for 1984/85 season is estimated to 92.000 bags in total (market surplus of 53.800 bags) produced on 4 977 hectares by 4 637 farmers, Table 8. The main rice land is close to the Chambesi river banks in Kasama and Chinsali districts. In Chilubi district the cultivation of rice is more important than maize growing in terms of cash crop production, Table 9.

7.2 Field level for the most important crops

Table 10 indicates the yield level for the most important crops grown in the province. It refers to four different sources, of which two state the average yield obtained in two different experimental series in the province. The third source gives the estimated yields if recommended cultivation practice is followed and if fertilizers are used. The last one gives possible variations in yield levels.

Table 10. Yield level of the most important crops grown in Northern Province. The figures in brackets refers to number of trials, (1) shelled ground-nuts, (2) cassava flour

	Maize	Millet	Sorghum	Beans	Groundnuts	Cassava	Rice
1) Central Statistical office (70/71): average yield	1532 (188)	2603 (283)	1500 (20)	740 (123)	1324 (1) (171)	2153 (2) (264)	–
2) Mansfield (1974): average yield	2484 (15)	855 (15)	- -	243 (11)	385 (1) (12)	-	-
3) Research Branch (1979): estimated yield	2880	1440	-	900	972 (1)	-28t	2520
4) Acland (1973): yield usually between:	670-8520	450-500	550-1700	220-670	450-670	7500-10000	5000-5700

The average yield figures per hectare of different crops from practical farming in Northern Province are generally low, see item 4 in Table 8. At the same time the other figures in Table 10 obtained from agricultural research series demonstrate the crop potentials of increasing the yields when proper management is practiced. It is, however, obvious that further agricultural research is needed to find alternative farming system methods from which farmers at different levels can benefit from.

8. FARM CROPS IN THE NORTHERN PROVINCE

8.1 Maize (Zea Mays)

Maize is widespread throughout Zambia. The acreage utilized for maize cultivation is remarkably high (Schultz 1976). Nevertheless, import is necessary to meet the national demand. The policy is primarily to achieve self-sufficiency inside the country and then build up national reserves as buffer stock. Secondly, there is a wish to produce a surplus for export (Zambian Government 1978).

In the Northern Province, little maize is grown compared with other parts of the country. The government is making efforts to increase the maize production in this province. The figures in Tables 7, 8 and 9 indicate the farmers positive responce to the Government programme. Views differ, however, as to whether this is a realistic policy or not.

Mansfield et al. (1978) claim that soil conditions in the Northern Province are not suited to maizegrowing. Dumont (1979) adds that maize will lead to increased soil exhaustion. Vikan (1981) says that there are farms growing maize with satisfactory results, and that it is possible and realistic to increase the production in the province.

Plant characteristic and ecology

Maize is grown in areas under conditions varying from tropical rain forests to steppes. Best results are obtained in regions with warm rainy seasons (summers) and quite a lot of well distributed rain.

The young maize plant is moderately drought resistant, but is usually sesceptible to unfavourable soil air/moisture relationships during the first four or five weeks after planting. Waterplogging in this period causes a shock from which the plant never recovers. Experiments from Kitale, Kenya, indicate that the optimum rainfall during the five weeks after sowing is 200 mm (Acland 1973). From five weeks onwards the maize plant is less drought resistant. The most critical period is at silking when a small degree of wilting can cause incomplete pollination, and when a severe drought can cause crop failure. The experiments at Kitale showed that, within the limits of rainfall experienced, the more rain that fell after five weeks the higher the yield became. Dry conditions are needed towards harvesting.

The maize grown in Northern Zambia, mainly belongs to the groups Indurata and Amylacea. The protein content in maize is not high and the quality is poor. Protein represents 9 - 10% of the grain and includes little of the essential aminoacids lysine and tryptophan (Norton 1978).

Recommendations for cultivation

Recommended fertilizer level is 200-300 kg/ha 'x'-comp. (20% N, 10% P_2O_5, 5% K O, 10% S) or 300-400 kg/ha 'D'-comp. (10% N, 20% P_2O_5, 10% K_2O, 10% S) as basal dressing, and 200-400 kg/ha Ammonium Nitrate (34% N) or Urea (46% N) as top dressing.

The seed rates vary according to size, shape and variety; 17-34 kg/ha. All certified seed is sold dressed with Captasan M. In the Northern Province the varieties SR 52 and ZH 1 are recommended. SR 52 responds better to higher inputs and is generally favoured for commercial production. ZH 1 is capable of giving yields comparable to SR 2 up to 5 tons/ha, at medium input levels. Due to heavy prolonged rains the growers are advised to plant on ridges, spacing between rows 75 - 90 cm and 23 - 25 cm inter plant, sow depth 5 cm. The optimal date for sowing depends on the early rains. Research Branch (1979) recommends late November to early December - just after the good rains. Northern Province, Ann. Report (1978/79) recommends 1 - 15 November as the best sowing-time.

Weeding is needed at least twice during the growing season. Spraying is recommended where stalkborer, Fat John and Corn root worm damage is recorded as serious. When plants are about 0.5 m tall, it is time for top-dressing. Estimated yield when these recommendation are followed, is about 3000 kg/ha in the Northern Province. (Research Branch 1979, Northern Province, Ann. Report 1978/79 and McPhillips 1979).

Pests and diseases

A list of pest and diseases damaging maize most frequently in the Northern Province may be:

Pests	Recommended spraying
a) Stalk borer, Busseola Fusca	D.D.T. or Endosulfan
b) Fat John, Dereodus sp. or Diaecorderus sp.	Aldrin or Carbofuran
c) Corn Rootworm, Buphonella murina	Aldrin
d) Black Maize Beetle, Heteronychus spp.	Dieldrin

Diseases

a) Cop Rots, Diploida and Fusarium spp.
Crop rotation and burning of plant residues.

b) Maize Streak Virus.
The virus is spread in the field by a leaf hopper, Cicadulina mbila.
Early sown crops are rarely attacked.
(McPhillips 1979 and Research Branch 1979).

Research work

See report 1, item 5.2.

Main constraints faced by maizegrowers

Haug (1981) made three studies among maize growers practicing different production systems in Chisanga, Mwenesauso and Chitoshi villages.

Below is listed a summary of constraints faced by the three different households and if recommended cultivation is practised or not.

The cultivating systems were:

1 = Chitemene and semipermanent hoe cultivation, 0.6 ha maize.

2 = Semipermanent hoe cultivation, 4.5 ha maize.

3 = Semipermanent to permanent hoe and oxplough cultivation, 2.5 ha maize.

a) lack of suitable land:	3
b) lack of manpower(draughtpower	1, 2 (and 3)
c) fertilizer application later than recommended (because of the riskfactor)	1, 2 and 3
d) just one weeding	1 and 2
e) too late harvesting (The cobs should been harvested at maturity and not been dried standing in the field, but in bins. This practice reduced yield-losses.)	1, 2 and 3
f) storage problems (rotting)	1, 2 (and 3)
g) pests and disease damage	(1,2) and 3
h) monocropping	1 and 2
i) more than four years fallow period is needed to maintain fertility	1, 2 and 3
j) lack of hand- and oxen tools	1, 2 and 3
k) lack of capital (which leads to unsufficient seed and fertilizer rates)	1, 2 and 3
l) marketing and distribution problems	1, 2 and 3

Each system includes variations which are not mentioned in this generalized description. For detail information see Haug (1981).

Labour consumption

Lack of man power/draught power is a main constraints for increased maize production. Mansfield et al. (1975) have estimated cropped areas for different labour input systems based on maize as the main crop.

F = a family of 4		Cropped area in ha
F,	hoe cultivation	2,0
F +	some causal labour at peak periods	3,3 - 3,6
F +	2 oxen	3.7
F +	2 oxen + some tractor assistance*	5.0
F +	4 oxen	6.0
F +	4 oxen + some tractor assistance*	7.0

* tractor is only used for primary cultivation.

Maize cultivation is more labour consuming than finger millet when it comes to field-preparation, planting, applying fertilizer and weeding, but less labour consuming as regards harvesting (Mansfield 1974). The shelling of groundnuts and beans is more labour consuming than the shelling of maize.

High protein containing varieties

Maize has as mentioned relative low protein content and poor protein quality. Unilateral maize diet may leed to kwashiorkor (protein deficiency disease) which might cause irreversible damage of the brain. Two maize mutants are known with considerable high protein content, Opaque-2 and Floury-2, the lysine content may be doubled according to ordinary varieties, without reduction in yield (Cimmyt - Purdue 1975).

It is desirable to introduce high protein containing varieties in

Zambia. This may mean a lot for people living mainly of plant diet with maize as the most important element.

Maize production in the Northern Province - future aspects

Heide and Aresvik (1980) say that it must be considered seriously if it is wise to continoue giving priority to maize production in the Northern Province. They put forward the following arguments against the maize production strategy:

a) It is experienced that yields decline radically in maize trials over time.
b) Maize offers little shelter or protection for the soil, and heavy rains will distort the soil structure profoundly.
c) The strongly leached sandy soils are poorly suited for maize growing.

In spite of these arguments, there are aspects which may support maize production in the province:

a) Mansfield et al. (1975) stress that crop rotation is one of suppositions for obtaining satisfactory maize crops in the Northern province. The cultivation must take place in combination with crops having similar extension programmes and market possibilities as maize.
b) The soil may be protected and improved by mulching etc. in such a way that maize do not impoverish the soil (IITA Research Highlights 1978).
c) Suitable soils for maize growing can be found in pockets spread around in the Province (Vikan 1981).
d) Maize is the most important element in the daily diet in Zambia. Today, import is necessary to cover the demand. Varieties containing better essential aminoacids, lysine and tryptophan will improve the daily diet.
e) Maize may be used both for sale and self-consumption. This gives maize a crop flexibility. In years with poor yields, maize may be used exclusively for subsistence purposes.

f) A lot is already done, encouraging the farmers to produce increased quantities of maize, e.g. through extension work and information. It may wise to build further on this and not leave this policy completely.

g) There seems to be few other crops than maize which are suited for both sale and selfconsumption, except for the traditional crops. Maize should be a supplement to these crops. After all, it is the traditional crops which are best adapted to the soils and climatic conditions in the province.

i) Mixed cropping with maize in a traditional cultivation method but with low productivity. The method need to be improved.

j) The traditional way of growing maize is labour consuming. Methods to sunplyfy the cultivation technique must be developed.

8.2 Finger millet (Eleusine coracana)

Finger millet is still the most important substistence crop in the Large circle chitemene region. Because it does not lend itself easily to a mechanical harvest, while at the same time it does well in areas where more demanding crops would hardly survive, it remains restricted to the subsistence farming system. According to this peculiar situation the crop is not regarded as an important component of Zambias agriculture and it has received little attention. Experiments have proven its capacity for good yields (Sarmezey 1978).

The small farmers in the chitemene regions give preference to millet cultivation to cover the households food consumption. What is left of time and labour might be used for sale production, e.g. maize or sunflower (Stølen and Archetti 1981). If possible, the millet cultivation could be made more effecient; and time and labour would be released and maybe used to increase the cash crop production.

A more efficient millet cultivation might also lead to a surplus which could be sold, depending on the market and marketing conditions. In Table 8 is forecasted the finger millet production in Northern Province in 1984/85 season. The production is commonly practiced among farmers. Only a small proportion of the produced millet is sold to marketing organisations.

Plant characteristics and Ecology

Finger millet requires a steady supply of soil moisture if good yields are to be obtained, but tolerate dry spells in early stages of growth. The initial growth is rather slow and it cannot compete well with grassy weeds, especially with *Eleusine africana* and *Eleusine indica*. In general, while it can grow on a wide range of soils, the best results are obtained from areas where fertility conditions are adequate. Tolerance to soil acidity is high. Different from other millet species millet and sorghum, it is not attacked by birds although occasional damage can occur.

The grain stores well with no pests. As a whole, finger millet suffers little from diseases and pest. India blas (*Piricularia oryzae*) can occasionally be severe and cause yield losses. The nutritional value of the grain is quite good among the millets. It is high in calcium and it does also have a fair amount of phosphorous. Its protein content is not high but of good quality. Compared to other cereals it has a favourable amino-acid composition. The straw is not much used in Zambia, but the quality is considered excellent. It is found superior to the straw of wheat, rice and sorghum. Table 11 shows chemical composition of grain and straw of finger millet.

Table 11. Chemical composition in grain and straw of finger millet (Sarmezey 1978)

	Grain	Straw
Moisture	11.6	9.9
Ash	2.3	12.1
Crude protein	7.8	2.2
Fat	1.3	2.4
Fibre	3.6	28.2
Carbohydrates	72.4	44.9

Finger millet responds well to moderate fertilizer rates. Obtained yield varies between 500 - 400 kg/ha (Acland 1973). Finger millet is very reliable, even under circumstances where other cereal crops would have failed or given negligible yields (Sarmezey 1978).

Research work

The yield of finger millet might be considerably increased by using improved varieties and fertilizers. Recommended fertilizer rate is 200 kg/ha Sulphate and Ammonia applied six weeks after planting as topdressing. The response to phosphorous has been less noticeable than the nitrogen response. Significant yield increase regarding phosphorous has been noted on virgin land only. Lime-application is not necessary for finger millet, which do well on acid soils (Sarmezey 1978).

Table 12. Finger millet nitrogen fertilizer trial (Sarmezey 1978)

Treatment	Yield kg/ha
N_o, Control	1670
N_1, 112 kg/ha calsium ammonium	2959
N_2, 224 kg/ha sulphate	3691
Mean	2773

Table 12 shows the response of finger millet to fertilizers. The obtained yield was doubled from the control to the N -treatment.

Table 13 shows finger millet rotated with groundnuts in a fertilized chitemene plot.

Table 13. Maintenance of fertility after chitemene using fertilizrs. Finger millet and groundnuts. Yield in kg/ha (Sarmezey 1978)

	1959-60	1960-61	1961-62	1962-63
Treatment	groundnuts	millet	groundnuts	millet
1. Control	773	1747	404	402
2. 49 kg/ha am. sulphate + 56 kg/ha lime	705	2317	454	1248
3. 112 kg/ha superphosphate	747	1546	501	529
4. 112 kg/ha superphosphate + 49 kg/ha lime	760	2153	521	1058

The trial in Table 13 tests the possibilities for maintenance of fertility after chitemene, using fertilizers and lime. The yield decreased rapidly in spite of the fertilizer and lime application, but a response to sulphate of ammonia and lime was obtained. Further research is needed to elucidate this.

The trial in Table 14 tests the possibilities for maintenance of fertility in the Grass mound system, using fertilizers and lime. The different treatments have little effect on groundnuts, but both fertilizers and kraal manure increase finger millet yields at about the same rates.

Finger millet is generally broadcasted in Zambia. Experiments have shown that drilling might be superior to broadcasting. The advantage of drilling is more even stand height and easier cultivation, especially weed control and harvesting. If the conditions are at their optimum which is rarely the case, drilling is not superior to broadcasting (Sarmezey 1978). The disadvantage with drilling practice is the labour requirements for making the drills. However, on weed infested land it might be labour saving in the long run to make the drills.

Table 14. Maintenance of fertility in the Grass mound system using fertilizrs. Finger millet and groundnuts. Yield in kg/ha (Sarmezey 1978

Treatment	1959-60 groundnuts	1960-61 millet	1961-62 groundnuts	1962-63 millet
1. Control	995	1433	562	303
2. Kraal Mambwe 11.2 t/ha (to millet)	1083	2249	566	666
3. 73 kg/ha am. sulphate + 84 kg/ha lime	957	2021	521	451
4. 73 kg/ha am. sulphate + 168 kg/ha lime + 224 kg/ha 'D'-comp. (to g.nuts) + 224 kg/ha am. sulphate (to millet)	1002	2249	524	626
Mean	1009	1988	543	511

Breeding

Breeding with finger millet started in the early sixties at Mount Makulu. A high yielding variety, M 144, was produced. It was very susceptible to lodging and had less than desirable grain colour. Through breeding programmes the high yielding ability of M 144 has been combined with lodging resistance and a more acceptable grain colour. Today, Steadfast, derived from an outcross of M 144 x Lime 197, is recommended for all areas of Zambia, especially where management level is good (Sarmezey 1978).

Table 15 shows a trial with high yielding varieties, mean yield is 3877 kg/ha. Sarmezey (1978) claims that further variety improvement is not required at present because the yield capacity of present grains is not fully utilized by the farmers. The reason for this is that:

a) The high yielding varieties do not reach the farmers because of e.g. the distribution and supply situation combined with lack of purchasing power and credit facilities.

b) Necessary inputs to utilize the yield capacity of the high yielding varieties is missing among the small scale farmers.

Table 15. Finger millet variety trial (Sarmezey 1978)

Variety	Yield kg/ha	Lodging	Crude protein
M 144	4188	2	8.50
Line 197	3755	0	9.27
Line 203	3644.	0	9.82
Steadfast	3689	0.6	
Line 89/74	4110	0.6	
Mean	3877	0.6	

[1]0 = nil, 5 = severe,
Misamfu R.R.S. M.N. 1591, 1968 and 1969.
Fertilizer: 200 kg/ha superphosphate + 200 kg/ha am. sulphate planted on virgin land.

Research work should rather concentrate on harvesting problems, especially testing mechanical equipment. Research work should also extend into the technology of the harvested product. Further breeding programme might seek to increase the protein content and malting quality.

Problems concerning finger millet and possible ways of expanding the production

a. Because of low soil fertility, it is not possible to cultivate finger millet permanently more than 3 - 6 years, even in rotation with legumes.

b. Harvesting requires a lot of labour. Preference should be given to research for improved harvesting methods.

c. The possibilities of using the crop for hay and grazing should be elucidated.

d. The contified seed production of Steadfast should be increased and the distribution improved.

e. More attention should be paid to finger millet production e.g. through extension work and in the Lima programme.

d. Marketing should be organized better by NCU.

Sarmezey's (1978) conclusions are that because of finger millets high yield capacity and reliability, it is a safe and profitable crop in the high rainfall areas. Therefore a consideration of an expansion in production might be well justified.

8.3 Bulrush millet (Pennisetum typhoides)

Plant characteristics and ecology

Bulrush millet has a very limited distribution in the Northern Province. Some places it is grown mixed with other crops. The advantages of bulrush millet is that it is both drought resistant and drought evading and gives reasonable yields on infertile sandy soils which would be unsuitable for the other important cereals. Today, however, it has been replaced by maize most places in Africa. The reasons for this are:

a. It has a lower yield potential than maize

b. Bird damage sometimes causes a complete crop loss

c. Threshing and winnowing are more laborius than for maize

d. Little attention has been paid to bulrush millet regarding extension, research and marketing.

Bulrush millet should not be given attention in the Soil Productivity Research Programme.

8.4 Sorghum (Sorghum vulgare)

Sorghum is not as common as it used to be in the Northern Province. Information about production, see Table 8. It has more or less been replaced by maize and/or cassava. Today it is mostly grown mixed with other crops. There exists 15 different sorghum species. Five of these are main species and ten are intermediates or combinations between those five. In Northern Zambia the kafir sorghum is mainly grown (Trapnell 1953).

Plant characteristics and ecology

Sorghum is very drought resistant, and might outyield maize under dry conditions, which is not the situation in Northern Province. It is also one of the few crops that withstands short periods of water-logging. Sorghum grows best on reasonably fertile soils, but is second only to bulrush millet in its ability to give satisfactory yields on soils that have been exhausted by previous cropping (Acland 1973).

Problems concerning Sorghum

The reason why sorghum has been replaced by other crops are similar to that of bulrush millet.

a. Low yield potential
b. heavily attacked by birds

c. harvesting, threshing and cleaning are more labourious than for other crops, e.g. maize.
d. Suspectible for pests during storing
e. Regarding extension, research and marketing low priority has been given to sorghum.

Sorghum production in Northern Province - future aspects

A reintroduction of sorghum in the province might be an alternative, but it seems more reasonable to give backing to finger millet which is the staple crop among the small farmers in the province today. However, intensive breeding programs for dwarf variety types with high yielding capacity are carried out at many international research centres. Such new gene plant materials should be tested under the climatic and edafic conditions in Northern Province.

8.5 Rice (Oryza sativa)

Rice is not a traditional crop in the Northern Province. Rice cultivation takes mainly place in flood plains, especially along the Chambeshi River in addition to scattered cultivation found in the dambo-areas in the province. The policy regarding rice production is primary to satisfy the national market. Zambia is today importing rice (Mansfield et al, 1975). Rice is doing well in the Northern Province where rain is sufficient for the cultivation, and flood plains and swamps exist. IRDP (1981) says that rice might become a suitable cash crop for the farmers in the province. The households might also start using rice for subsistent purposes.
Figures about rice production in Northern Province are presented in Tables 7, 8 and 9.

Plant characteristics and ecology

There are three different rice cultivation techniques:

a) dryland or upland rice
b) swamp rice
c) floating rice

Rice prefers high temperature and grows best below 1300 m. Sandy soils can support good crops if rice provided that there is a permanent high water table. However, a heavy soil is needed to retain the irrigation water. Rice might be

a) broadcasted
b) sown in rows
c) transplanted

The protein content is not high, but is is of good quality. During milling and polishing valuable protein, minerals and vitamins are removed (Acland 1973).

Pests and diseases

There are two fungis which are easily spread in areas with continuous rice cultivation. That is Blast (Piricularia oryzae) and Brown Spot (Helminthosporium oryzae). These diseases may cause serious damage if not dressed and clean seed or resistent varieties are used (Edou 1977).

Rice projects in the Northern Province

SATEC (Societe l'Aide Technique de Cooperation) first came to Zambia in 1968 to carry out a three years extension programme with supporting research in the Northern Province. Three varieties were tested, one turned out promising, 1632 (Craufurd 1978). SATEC carried out a two years programme with upland rice. Out of 22 reported trials, only 5 gave a measurable yield. The reason for this failure was pests, diseases, birds and rat damage and drought. Five to ten days droughts occur nearly every year in the trial area, and the soils where considered to be low in clay. The conclusion drawn from these trials is that upland rice will not succeed without supplementary irrigation. Swamp rice seems to be a better alternative e.g. to utilize the damboes in the province.

SATEC introduced a number of implements developed for the small rice farmer. In their original forms these were designed for use on the more easily worked upland soils, and when SATEC turned their attention to dambo rice, they experienced a number of problems. A single row weeder was manufactured and sold locally.

Unfortunately manufacture stopped, otherwise many more would have been sold. A pedal tresher became very popular. The original model was heavy and difficult to move, but modifications have been made to improve it. A multiseeder, which could be operated by one man and which could sow a range of crops, was also introduced (Craufurd 1978). These implements might decrease the labour requirement in rice cultivation considerably.

Nashinga Rice Scheme. This scheme was initiated to test the economic possibility of large scale direct production of rice. In 1969, 13 hectares of upper dambo/dambo fringe were cleared and prepared with tractor. Results were disappointing and in 1969/70 the scheme was reduced to 4.4 ha of seed multiplication and 2 ha of variety trials. Once again the results were disappointing. Net losses represented 180 Kw/ha. The highest yield obtained at Nashinga was 1829 kg/ha (variety 1632) and 1278 kg/ha (variety 1345). The scheme was decided abondoned until cultivation techniques are improved (Mansfield et al. 1975).

Direct Production Schemes. In 1979 there were 15 small rice production schemes dotted all over the Northern Province. About 90% of them were financed by Agricultural Capital Development Funds (Northern Province Ann. Rep. 1979). In addition IRDP conducts a good number of subsidized rice production schemes in their programme areas. IRDP has also improved SATEC's pedal tresher and builds simple models from old bikes.

Research work in the dambos

Research Branch in Zambia resumed rice trials in dambo-areas in 1971. These trials were not successful. The reason for this was supposed to be wrong trial-siting in the dambos (Craufurd 1978). A dambo survey was undertaken to classify the dambos, and to see whether there were any consistent features which could be used to identify suitable rice growing areas within a dambo. The conclusion was that the majority of dambos are suitable for rice production, and that within a dambo there are two zones which are easily recognized and which are suitable for rice growing. These zones are the peaty soils of the seepage zone and the heavy clay soils of the central parts of the dambo. At present the peaty soils are the most widely used because of their ease of access, and because they are less vulnerable to uncontrolled flooding. Indicator plants can be used in site selection. The grass Miscanthidium terctefolium is a good indicator whose presence seems related to the depth of peat. A sufficient peat depth is important so that the underlying sand is not disturbed by cultivation. The heavy clay soils of the central parts of the dambo usually dry out sufficiently to be ploughed by tractor. Trials suggest that the yield potential is higher in these soils, but not as reliable as in the peaty soils (Craufurd 1978).

Dambo rice - recommendations for cultivation

Recommended fertilizer rate is 200-300 kg/ha 'D'-comp. as basal dressing and 100 kg/ha Am. Nit. as topdressing. The top dressing should be applied 6 weeks after sowing. Optimal seed rate is about 60 kg/ha of the varieties 1632 or Sindano (McPhillips 1979).

The seed is sown mid-late November, on drills in rows 20 - 25 cm apart and 10 cm interplants. Weeding is needed at least once. If weeds are regarded as a great problem, transplantation of seedlings raised in nurseries are recommended. This is a highly labour intensive method. Early harvesting (when three quarters of the panicle has reached the mature ripe colour) is important, because the harvesting is time consuming and the rice plants are suspectible to loss due to shattering. Estimated yield following the recommendations for cultivation is 3000-4000 kg/ha, (McPhillips 1979), or 2500 kg/ha (Research Branch 1979).

Problems and possible ways of improving the rice cultivation

a) The lack of seed rice, of any quality, is a serious limitation to rice growing. Certified seed production should be increased and distribution conditions should be improved.

b) Rice production without any other implements than hoe is very labour consuming. The manufacturing of hand harrows, roe weeders and pedal tresher should be given priority and made available for the small farmers.

c) There is a lack of people knowing enough about rice management. Training for extension work is important. Today the rice is in general broadcasted, instead of planted in rows, too little fertilizer is applied, just one weeding is done and harvesting starts too late so that the growers suffer great grain losses. The conditions should be improved so that the farmers could get the chance to follow recommended cultivation.

d) Further work is needed to explore the dambos, the Nashinga swamps, the river flood plains and other possible ricegrowing areas.

e) New gene rice material should be tested in rice growing areas in Northern Province.

NCU is purchasing rice at quite good price. In 1982 the price was to increase to stimulate the production (Dept. of Agriculture 1981). In addition NCU must try to collect the produce and make the payments on time.

Rice might become a supplement to the traditional crops even if the production is labour intensive. Such production utilizes the dambos and the flood plains which ordinary are not used during the wet season.

Wheat (Triticul aestivum)

Irrigated wheat-growing in the dry season has taken place in Zambia during the last 40 years, but rainfed wheat production is more recently introduced. In the Northern Province this production started in 1974. This policy is to motivate more growers to undertake production so that flour demands can be met and the inflow of flour imports curtailed.

Rainfed wheat production has not been successful in the Northern Province, mainly because of the acid, unnutrient soil, but also because the crop is strongly attacked by several pests and diseases during the rainy season (Mansfield et al. 1975). Pexco-minutes (1981) at Misamfu RRs concluded that there were no reasons to encourage the farmers to grow wheat in the Northern Province. In Tables 7, 8 and 9 production figures of wheat in Northern Province are presented.

Plant characteristics and ecology

Wheat is one of the most important cereals in terms of total world production. Although wheat is usually considered a temperate-zone crop, it is also grown during the cool season in semi-arid areas in the subtropics and tropics in equatorial areas it grows best at altitudes of at least 1800 m.

Wheat needs a minimum of 250 mm of well-distributed rainfall. The crop is drought tolerant. Ear initiation is the most critical period as regards water supply. High temperatures may retard heading and many cause the crop to ripen prematurely after flowering. Best suited to wheat are medium to relatively heavy soils with good internal drainage. The crop is moderately resistant to salinity.

Research work

A difficulty in wheat growing in the Northern Province is to find the right time for sowing. Too early sowing leads to pests and diseases strongly affecting the plants. When the sowing is done too late the growing season becomes too short. February - March is recommended suitable planting time. But because of annual variations it is no insurance for satisfactory yield to follow the recommendation. The most common diseases on wheat in the Northern Province are Helminthosporim sativum and Fusarium spp. (Zam-Can 1980).

At the Zambia-Canadian wheat project (Zam-Can) near Mbala, several experiments and observations concerning rainfed wheat have been undertaken. They claim that lime is a necessary supposition for obtaining satisfactory yield. The problem is to work the lime down deep enough in the soil to satisfy the wheat roots demands.

Table 16. Fertilizer trial with wheat (Zam-Can 1980)

Treatments N	P	K	S	Yield kg/ha
0	0	0	0	375
0	60	80	30	580
Amm. Nitrate				
40	60	80	30	686
80	60	80	30	907
150	60	80	30	826
Urea				
40	80	60	30	923
80	60	80	30	947
150	60	80	30	864
Mean				764

Sulphur applied at 30 kg/ha gave significantly higher yields than no S. All rates of nitrogen gave significantly higher yields than no N. All rates of Urea (40, 80 and 150) and the 80 and 150 kg/ha rate of ammonium nitrate were significantly higher yielding than Am.Nit. at 40 kg/ha. There was no difference between the five higher rates. Higher rates of N reduced test weight. The low yields were due to the acid-soil/early drought problem.

Zam-Can has also carried out experiments with triticale (wheat x rye) for comparison with wheat. Table 17 shows a variety trial in wheat and triticale. The yields obtained are very low, Jupateco-73 is the only wheat variety which exceeds 1000 kg/ha. Triticale is superior to wheat regarding yields and 1000-kernel weight. The triticale variety IRA-CAL gives the best yield results.

Triticale is more tolerant to the acid soil than wheat, and is less attacked by pests and diseases. Triticale is thereby better suited for the conditions in the Northern Province. But the baking properties is not as good as for wheat (Zam-Can 1981).

Experiments carried out at Mwinilunga RRS in Northwestern Province have been similar disappointing as for the areas in the Northern Province. Top mean yield obtained has been 469 kg/ha of rainfed wheat. The irrigated wheat has done slightly better, but top yield have not exceeded 1500 kg/ha (Boer 1978).

Experience from IRDP

Integrated Rural Development Project (IRDP), have tried rainfed wheat production among farmers in some villages. One thought that wheat was a good crop for the farmers to grow because it is sown in February/March and does not compete with traditional crops as far as the sowing period is concerned. Wheat, however, does compete with these crops during the harvest time and has, apparently, low priority compared to the other crops. It is the last crop to be harvested - too late to get a good yield. The ears are broken, the seeds have partly fallen to the ground or been eaten by birds, thus complicating the harvest. Even if the wheat is harvested on time, harvesting is considered problematic because it has to be done by hand and is very time consuming. Threshing is considered another big problem as this also is very time consuming (Stølen and Archetti 1981). Obtained yields have been around 350 kg/ha. The seeds and the fertilizers have been given free by IRDP.

8.7 Groundnuts (Arachis hypogea)

Groundnuts are the most widespread of the leguminous crop, and very popular in the diet in the chitemene area (Richards 1961). The nutritional value is high and the crop is well suited for use in rotation systems. Groundnuts contain quite a lot of oil. There is lack of food oil in Zambia. The official policy implies encouragement of the oil crop production to reach national self sufficiency (Zambian Government 1978). NCU purchases groundnuts in the Northern Province. In spite of a very good price given to the producer, quite a lot is sold locally or to private merchants (Northern Province, Ann. Rep. 1979), see tables 7, 8, 9 and 20 about groundnut production and intake by marketing organisations in Northern Province.

Plant characteristics and ecology

The groundnut plant is a low growing annual legume. The roots are almost always well nodulated. The fruit is an elongated pod, developed in the soil and containing 1 - 6 seeds. Good distribution of rainfall is essential for satisfactory yield and ease of field operations. Groundnuts need a warm climate and do not endure frost. It is tolerant to shade and might be grown mixed with taller crops. The competition ability towards weeds are poor. The plant might be attacked by quite a number of diseases (Acland 1973, Duke 1981).

Table 18. Protein- and oil content in groundnuts (Opsahl 1980)

	% oil	% protein
nuts	40-45	25-30
flour	6	45

Diseases and pests

Leaf spots (Cercospora spp.. This is a fungi disease, spread by airborne spores, by infected thrash in the soil and, to a lesser extent, by infected seed. Damage can be reduced by early planting, seed dressing, crop rotation and the extinction of infected debris.

Rust (Puccinia argchidis) as for leaf spot.

Blast (Aspergillus niger). The fungus may grow inside the pods and infect the kernals. Rapid drying after harvesting and seed dressing reduces the damage.

Rosette: This disease is caused by a complex of at least five viruses. Aphids (Aphis craccivora and possibly A. gossypii) transmit the viruses. If the plants are infected when they are young they may produce no nuts. Sowing as early as possible and using a close spacing reduce rosette damage, but it can only be completely checked by using insecticides.

Problematic pests can be groundnut hopper (Hilda patruelis) and jarrids (Empoasca facialis) (Acland 1973, Duke 1981).

Pops

Pops are not just an empty shell, which is the worst manifestation of a condition typified by kernals not developing properly. It also includes the problem of shrivelled nuts for instance turning dark instead of normally white to yellow plumules in light shrivelled nuts (Mansfield 1973).

Drying unripe groundnuts can also cause shrivelled nuts, but this is not defined as pops. Pops occur when the embryo is aborted or retarded in growth. This is to a greater extent a problem concerning improving varieties than local grown material (Mansfield 1973).

Pops appear to be associated with the need for calcium between 10 - 30 days after the gynophore enters the ferriting medium. The condition seems typified by a metabolic malfunction as carbohydrates and fats are not laid down in the normal fashion. The availability of calcium within the plant appears to be affected by the level of calcium in relation to other elements, although these have not been proved to be either soil magnezium or leaf boron. More than 75% defecture kernals occurred when soil pH fell below 4.6 and less than 25% occurred when pH was above 5.2.

Relationships have been sought between pH, calcium/magnesium ratios and calcium as a percentage of the CEC, but no approach here was yet given the answer to explain the connection between Ca in the soil and amount of "pops". There does appear to be some evidence that the soil potassium/calcium ratio may be related to the severity of "pop" once exchangeable calcium falls below 1.5 Meq%. This is illustrated by the results obtained in 1968-69 at Misamfu as shown below.

Table 19. The relation between pops, exchangeable calcium and the soil potassium/calcium ratio (Mansfield 1973)

Exchangeable soil Ca	Soil K/Ca ratio	'% pops'
1.05	0.229	28.9
1.05	0.276	29.9
1.05	0.333	45.7
1.50	0.247	10.5
2.00	0.222	5.6

Recommendations for Cultivation

When groundnuts are grown in rotation with fertilized crop, fertilizer application is not needed. On virgin land or low fertility sites 200 - 300 'D'-comp./ha or single supers are recommended. On acid soils lime aoolications are strongly advised because of pops. Critical pH-level is about 4.6 on sands and 5.0 on sandy clays.

Recommended varieties are Makulu Red and Cobberbelt Runner, the last one is best on pops suspectible soils. It should be planted on ridges, seed rate 80 kg/ha, as early as possible in the growing season, e.g. with the first rains in November. Harvesting and shelling are very labour intensive operations (McPhillips 1979, Research Branch 1979).

Research work

There exist two different groups of varieties:

a) Spanish-Valencia section (sequential branching)
   90 - 100 days to marity

b) Virginia section (alternate branching)
   120 - 150 days to marity

The Virginia section is the one grown in the Northern Province. Because of the long rainy season, the section is well adapted to the climate in the province. However, promising results with the Spanish section have been obtained. The trials have been performed without lime application in acid and sandy soil. Further research is needed to prove whether the Spanish section might be a better alternative than the Virginia section in the province.

Future aspects

Groundnuts are mainly grown as subsistence pulse crops, but they can as well be manufactured and used for cooking oil, margarine or salad oil. Other possibilities are confectionary nuts or protein anamal feed. To make the farmers able to increase their groundnut production, it is important to develop:

a) a labour saving harvest- and shelling technique
b) an efficient way of controlling weeds
c) improved varieties, lime etc. is made available for the farmers
d) research work with the Virginia section
e) research work with groundnuts mixed with other crops.

8.8 Beans (Phaseolus vulgaris)

Beans is a traditional and widespread crop in the Northern Province. See Tables 7, 8, 9 and 20 for bean production trade and producer prices. As for groundnuts the nutritional value is high and the crop is well suited for use in rotation systems. Both groundnuts and beans might be grown for subsistence and cash crop production, and are purchased by NCU. The advantage of beans compared to groundnuts is that beans are not affected by pops. Therefore beans might replace groundnuts on pop-exposed soil.

Plant characteristics and ecology

Beans are not drought-resistent, ideally they need moist soil throughout the growing period. High temperature might cause poor fruit set, therefore they are best suited to the medium altitude areas from 900 up to 2100 m.

Beans demand free draining soils with a reasonable high nutrient content. Pests and diseases can become a big problem in the cultivation. The protein content is high and the protein quality is very good (Acland 1973, Duke 1981).

Pests and diseases

Bean fly (Melanagromyza spp.). This fly is the most damaging beanpest in the Northern Province. Damage can be prevented by early planting, crop rotation, seed dressing and the removal of crop residues.

Anthracnose (Colletotrichum lindemuthjanum). This fungi disease is spread by infected seed, by infected trash in the soil or by spores splashed from the lesions. Damage can be prevented by growing resistant varieties, crop rotation, destruction of crop residue, by always using clean seed and by spraying with pesticides.

Angular leaf spot (Phaeoisariopsis griseola). The spores are spread by infected seed and trash, by wind, and locally by rain splash. Prevention as for Anthracnose.

Bean rust (Uromyces phaseoli). The spores are air-borned or by rain splash. Wet weather encourages spore germination and lesion growth. Rust can be avoided by growing resistant varieties, e.g. Mexican 142 (Acland 1973, McPhillips 1979).

Several other pests and diseases damaging beans exist; here the most common ones in the Northern Province are mentioned.

Recommendation for cultivation

Beans give good response to fertilizer applications. The amount of nitrogen fixed by the root system is usually too small to provide for a sufficient supply of nitrogen to the plants(Acland 1973). Recommended fertilizer rate is 200 - 300 kg/ha Am. Nit. as top dressing. Liming is necessary if the pH is less than 4.6 at sands and less than 5.0 at sandy clays (McPhillips 1979). Beans are sensitive to high concentrations of manganese, aluminium and boron (Purseglove 1979).

Five different varieties are suited for growing in the Northern Province, that is Misamfu Speckled Sugar, CB 609, Solwezi Rose, Mexican 142 and Nanzinde. Mexican 142 is most resistant towards diseases.

However, local seeds are usually used. All seeds are largely virus-infected and both local seeds and seeds sold by NCU/Namboard are infested by wevils. Seed quality is thus a constraint to bean production (IRDP 1981).

The seed is dressed with dieldrin and sown on ridges, 50 - 75 cm between rows and 10 cm interplants. It is possible to take two bean crops during the growing season, as they do in the Mambwe area. There, the first crop is sown in November and harvested in March and the second crop is sown in March/April and harvested in June (Stølen 1981). If just one crop is grown, it is common to sow quite late in the rainy season to avoid serious damage by pests and diseases (e.g. January-February). Too late sowing may lead to drought problems.

Research work

Investigations to test the effect of previous fertilizer management of maize on the following bean crop have produced results which are somewhat contrary to normal expectations (Copperbelt RRS). No significant effects were obtained from residual fertilizers applied to the earlier maize crops, while a significant yield response was obtained from the residual effect of liming. Direct fertilizer application produced by far the largest response where the best yields were obtained from the improved management practice (Melhuish 1976).

Trials in Zambia have also been carried out to investigate nutrition, population, cultural practices, disease and weed control, inoculation, management/crop rotations and cultivar aspects of production under different soil and climatic conditions found in Zambia. The main conclusions drawn were:

1. Applied phosphorous predominates in importance
2. Lime was the next most important nutrient, its residual effect being especially marked
3. Sulphur deficiency plays an important role in some localities
4. Inoculation trials have so far been unsuccessful
5. Inter-row spacing of 8 - 10 cm along rows, 6-75 cm apart should be used (Melhuish 1978).

At Uyole Agricultural Centre, Mbeya, Tanzania, extensive research on beans is carried out. Local germplasm has been collected and compared with introduced germplasm for evaluation of attack of angular leaf spot, rust, anthrachnose, bacterial blight and bean scab, and for growth habit, pod position and earliness, for yield, quality and acceptability (Uyole Agricultural Centre 1980A).

High-yielding imported bean ciltivars were destroyed by diseases before they gave any yield. Local bean types were low-yielding, but showed high resistance against diseases. They also experienced that the bean types ability to take up phosphorous from the soil varied. Again the local types showed the best ability to take up phosphorous (Hansen 1981).

"Kabanima" is an acceptable high-yielding cultivar with a tidy growth. It seems to have a high degree of resistance to anthracnose. "T 3" is also a high-yielding cultivar with resistance against rust and angular leaf spot. It is a small seeded red cultivar with about 4,800 seeds per kg. Recommended seed rate is 50 kg per ha. "T 3" is susceptible to anthracnose (Uyole Agricultural Centre 1980B).

Purseglove (1979) states that very little has been done on improvement of common beans in Africa and elsewhere in the tropics.

Grubben, Tindall and Williams (1977) state that local cultivars may have a greater degree of horizontal disease resistance and recommend collection of such cultivars.

Table 20. Quantities of beans and groundnuts traded by NCU 1976-81 and producer prices offered by NCU the last years

	1976	1977	1978	1979	1980	1981	1982
Shelled groundnuts, 80 kg bags	55	102	9	28	124	18	
Beans, 90 kg bags	914	2081	280	2738	20948	367	
Producer prices* groundnuts					63	45	55
Producer prices* beans					63	43	54

* In Kwacha/bag

Source: L. Gerhardsson, NCU 1982

The large quantity of beans traded by NCU in 1980 was due to the high price offered this year.

Future aspects

Beans are very important for people's diet in the Northern Province. In some areas it has also become an important cash crop. The crop potential regarding yield per hectare is not utilized to the optimum extent. A future programme should include projects like:

Testing of new gene bean materials both creeping, erecting and climbing types.
Cultivation methods (sole, mixed cropping).
Planting dates for different districts.
Crop rotation trials.

Soya beans (Glycine max)

Soya beans is a new crop in the province and the policy is to encourage the farmers to participate in the production of this crop in order to reach selfsufficiency. In 1979, total purchased produce by NCU was only 21 bags (Northern Province Ann. Rep. 1979)tables 7, 8 and 9. Soya is the most important crop in the world regarding production of vegetable oil and protein. The beans are virtually never eaten by the African farmers owing to the difficulty involved in cooking them. But is is possible to eat the seed, ripe or not, as vegetables. The beans have a high content of good quality protein (Acland 1973).

Plant characteritics and ecology

The general climate requirements approximate those of maize. A rainfed crop requires about 600 mm of well distributed rainfall with sunny periods in between. Dry weather is needed during maturing and harvesting. Soya beans have great adaptability to temperature. The crop is cultivated in temperate as well as in tropical climates. In terms of soils too, the requirements of soya beans are more or less the same as those of maize. Organic matter is less essential than for maize growing. A high calcium content of the soils is favourable. Poor growth occurs if root modulation is absent. Inoculation with Rhizobium spp. is then necessary. The soya bean is a suitable crop in rotation with gramineous crops. It may be sown in the stubble of a preceeding cereal without soil preparation. Because of the possibility of transmitting diseases it is not recommended to grow soya beans after tobacco.

Problems concerning soya beans - future aspects

An introduction of soya beans among the small peasant households in the Northern Province face the same constraints as introducing sunflowers. Soya beans are not used for self consumption, the cultivation is labour intensive and competes with the traditional crops both at sowing and at harvesting time. The yields are poor due to lack of necessary inputs, and low prority given the crop. Finally, soya beans is a new crop and the farmers are not familiar to the cultivation of this crop. In spite of this situation the crop should be given much more attention from the Department of Agriculture. Results obtained from research projects are very promising and indicate that soya bean has a future in Zambia agriculture. It is recommended that ongoing research projects on soya bean should be adopted to Northern Province conditions. Soil Productivity Research Programme should contribute in the projects.

8.10 Cowpeas (*Vigna unguiculata*)
are grown in the Northern province both for the leaves and the grains. There are two types, large creeping and small erect. The grain yields are low. They are not included in the LIMA programme. They can be grown on acidic soils. They are usually intercropped in Zambia.

Research work

The International Institute for Tropical Agriculture (IITA), Nigeria, carries out considerable research on cowpeas. In Zambia local and imported germplasm are evaluated. Cowpeas as a leaf vegetable is not considered in this research. It is recommeded that Soil Productivity Research Programme include the crop in the research programme both for the bean/leafy vegetable investigations as well as for soil fertility improvements.

8.11 Groundbeans = Bambara groundnuts (Voandzeia subterrane)

are commonly grown in Northern Province. This crop is neglected as far as research is concerned. In some parts of the country (Western Province) a collection of local varieties have been done and tested in ordinary trials. No encouranging results have so far - come out of the investigations.

8.12 Rhizobium research

Many tropical legumes can attain maximum growth in extremely acid soils, and some strains of Rhizobium are highly acid-tolerant, provided soil Mn levels are low. Manganese toxicity is one of the chief causes of poor nodulation of legumes in acid soils of the tropics (Pearson 1975).

Research work

Poor nodulation is very common in Zambia. Research is going on at Mt. Makulu with various legumes and Rhizobium spp. So far inoculation has not been successful for beans, but is recommended for soya beans. It is advised that Soil Productivity Research Programme should contribute in this type of research by recruiting a soil microbiologist.

8.13 Other legumes

Research Branch (1978) has conducted experiments with possible legumes for use in the different provinces in Zambia. None of

these have proved to be especially promising, but further work is needed for closer investigations;
Phaseolus lunatus (Limabean)
Vigna aureus/V. mungo (Gram)
Cyamopsis tetragonolobus (Guar)
Phasseolus mungo (Mungbean)
Phaseolus anguleris (Adsubi bean)
Canavalia ensiformis (Jackbean)
Vicia faba (Pigeon bean)
Cicer arietinum (Chickpea)
Phaseolus acutifolius (Tepary bean)
(latin names: Usher 1974)

8.14 sunflower (Helianthus annus)

Sunflower is included in the National Oilseed Development Programme, along with soya beans, groundnuts and cotton seed. The official policy implies encouragement towards oil crop production to reach national self-suffucuency. Sunflower is a new crop in the province. The small farmers do not seem very enthusiastic about the crop (IRDP 1981).

Reason for this may be:

a) Sunflower competes with the traditional crops both at sowing and harvesting time.

b) The farmers do not seem enthusiastic about crops which they do not consume themselves (Stølen and Archetti 1981).

c) The yields have been loww (IRDP 1981).

d) The crop is very prone to shattering, and birds damage can be severe (Acland 1973).

e) Harvesting and threshing is very labour intensive.

f) Sunflower is a new crop in the province, and the farmers are not familiar to it, regarding cultivation management.

The production and trade with sunflower in Northern Province is presented in Tables 7, 8 and 9.

Plant characteristics and ecology

Sunflowers are drought resistant, because of their deep roots. They may yield quite well on relative unfertile soils and are grown under different climatic conditions. The plants are productive and may produce 10.000 kg dry matter per hectare in stalks, leaves and heads as residue. These residues are well suited as green manure.

The oil extracted from sunflower seeds is of high quality; the oil content of the seeds is 20 - 50% depending on the variety. Other uses of sunflower include grinding the dried heads as cattle feed, ensiling the young plants and exportation as food for cage birds (Acland 1973).

Research

Results from sunflower trials carried out at Mwinilunga RRS (Northweatern Province) have been disappointing with a maximum yield in kg grain per hectare of 555, recorded for the earliest date of planting (6th December). This produce was of low quality because one had to harvest during the rains. The second date of planting trial was a complete failure and records of yields were taken. Variety trials have been similarly failures (Boer 1978).

Recommendations for cultivation

Sowing should take place early - mid January on rows; seed rate approximately 5 - 7 kg/ha of composite variety, CBG or hybrid seed, spacing 75 - 90 x 25 - 30 cm interplant. Recommended fertilizer level is 300 kg 'D'-comp. per hectare basal, and 200 kg Urea/Am.Nit. per hectare as top dressing. Estimated yield may be 800 - 1800 kg of seed per hectare. Shattering and birds damage are major problems in the cultivations.

Pests and diseases

Troublesome pests and diseases are:
Cutworm (*Agrotis spp.*), Nysius Bug (*Nysius sp.*), Leaf spot (*Alternaria helianthi*), Leaf Blotch (*Septoria helianthi*), Bacterial stem Rot (*Erwinia arvideae*) and several rust-species (Research Branch 1979, McPhillips 1979).

Future aspects

No doubt, sunflower is an important crop in Zambia and efforts should be make to encourage farmers in Northern Province to grow the crop. Through research programmes adapted to Northern Province climatic and edafic conditions the Soil Productivity Research Programme should contribute.

8.15 Cassava (Manihot esculenta)

Cassava was introduced in Zambia late in the last century. Today, cassava is grown by most households in the Large circle chitemene area (87%), at about 33% of the average farm acreage (Schultz 1976). The expansion of cassava has to be seen as a response to the breaking down of the chitemene system (Schultz 1976). The Government has been paying little attention towards cassava - extension and research work are by far neglecting the crop, and NCU is not purchasing cassava. Marter (1978) claims that cassava growing involves a large production potential and that only small improvements are needed to utilize this potential.

Plant characteristics and ecology

The main advantage of cassava is its drought resistance ability, its ability to give good yields on poor soils, it's resistance ability to pests and that it can be left in the soil as a famine reserve. Other factors which make cassava popular with growers are that it requires little labour, that there are no labour peaks because the necessary operation can be spread throughout the year and that yields fluctuate less than those of cereal crops. Cassava's limitations are its poor nutritive value and its cyanogenic glucoside content which can lead to hydrocyanic poisoning unless precautions are taken during preparation of the tubers (Acland 1973, Onwuema 1978). Cassava's nutrient requirements are very small, probably owing to the fact that the bulk of the crop consists of carbohydrate. The main need is that soils should be well drained. The soil type may affect the bitterness (Acland 1973).

Pests and diseases

Cassava is very little troubled by pests. "White scale" sometimes occurs, but as it is highly immobile, growers can effectively stop it by selecting clean planting material (Acland 1973).

"Mosaic" is by far the most serious cassava disease. It is caused by a virus which is mainly spread by the use of infected planting material, or transmitted by a white-fly vector (*Bermisia spp.*) (Onwueme 1978).

Yields

Table 21. Cassava yields (Marter 1978)

Yield (1)	Ton/hectare	
Category	Fresh weight	Dry weight (2)
Highest	36.3	12.7
Lowest	13.8	4.7
Average	25.6	9.0

(1) Based on yields from five plots each 25 m^2 in size

(2) Dry weight = 35% fresh weight

Table 21 shows results from trials carried out in the Western Province, average yield was 26.5 tons fresh weight per hectare, without fertilizer application. Average yield for the whole country is about 17 tons/ha (Marter 1978).

The protein content in the tubes is just 3%. The leaves are much more nutritious and have a dry matter content of protein of 36%. By using leaves and tops of cassava, it is possible to produce ten times as much protein per hectare and year than by growing rice (U-landsavdelingen, SLU 1980).

Labour consumption and profitability

The fact that cassava requires little labour and does not depend upon special inputs, makes it well suited for the small peasant households in the Northern Province.

Table 22. Labour requirements for selected operations in cassava compared with maize, hours per ha and year (Marter 1978)

	Cassava	Maize(1)	Maize(2)
Preparation	318	294	201
Planting	36	42	
Weeding	94	140	351
Applying fertilizer	-	28	-
Harvesting	-	-	-
Total	448	504	552

(1) Jonson, J., 1977. Maize requirements using handcultivation.

(2) Bessel, J. E., 1973. Maize requirements for handcultivation, rows without spacing.

Table 22 shows that preparation is more time consuming in cassava than in maize. The reason for this is that cassava is planted on ridges and maize on flat land in the trial referred to above. Harvesting is not included in the trial because it is difficult to give exact figures for the spreadout way of harvesting cassava.

Table 23. Seasonal labour requirements for cassava compared with maize, labour includes preparation, planting and weeding in hours per ha (Marter 1978

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Maize	67	121	198	158	8	-	-	-	-	-	-	-	552
Cassava	5	7	47	81	97	90	43	24	16	12	10	8	448

Table 23 shows that there are no labour peaks in cassava growing, because the necessary operation can be spread throughout the year. This is a problem (when growing maize), where the labour demand in December and January are critical factors.

Breeding

At the International Institute of Tropical Agriculture (IITA) high yielding varieties have been developed. The most promising varieties are TMS 30555 and TMS 30572. They produced average yields of 40.8 and 36.0 tons/ha in 12 months. TMS 30572 had a very high yield of 68 tons/ha in 15 months without fertilizers in a field at IITA where cassava was consecutively planted for two years without fertilizer application. Other advantages of both varieties include: 1) Less of a weed problem because the canopy of the plants develops rapidly. 2) Their resistance to mosaic disease, bacterial blight disease, root rot disease, and lodging. The varieties are also relatively low in cyanide content, have a good tuberous root shape, their quality is rated "excellent" for consumer acceptance, and the percentage of dry matter is relatively high.

A wide range of environmental conditions have been covered during the testing of the varieties, from areas with high rainfall and sandy, acid, poor soils to savanna areas with a longer dry season and relatively low rainfall (IITA Research Highlights - 1979). It is highly recommended that Zambia should test the new breeding materials from IITA.

Harvesting cassava

At IITA development of a simple hand lever to gently ease the cassava root out of the soil is hoped to enable at least a five-times increase in productivity as experience and skill with the tool is developed. With the tool the effort of lifting is reduced to one third that usually required and further eliminates the need for maintaining a tight grip on the stem. Springloaded jaws grip the stem as the fork of the lever is eased around it, and tighten with the pressure of lifting. The stems need to be cut about 50 cm above the soil surface before harvesting (IITA Agriculture Engineering Programme 1978).

Future aspects

a) Improving the market situation e.g. NCU starts purchasing cassava
b) Cassava should be forwarded through information and extension
c) Research work concerning cassava should be undertaken:
   - investigate local varieties
   - cultivation on flat land compared to ridges
   - possible rotation systems
   - mixed cropping
   - the effect of cassava in the daily diet
   - possible supplementary protein sources
   - appropriate hand- and oxen equipment to increase the productivity.
d) Introducing high-yielding varieties and appropriate tools from IITA.

8.16 Coffee (Coffea arabica)

In Zambia, coffee production is almost exclusively confined to Northern Province, where climatic conditions are favourable for coffee. Today, Zambia is importing coffee to meet the national demand. The policy is first of all to try to reach self-suffuciency, then eventually enter into the World Market (Northern Province An. Rep. 1979). The farmers in the province have the opportunity to buy cheap coffee seedlings, subsidized by the government. However, coffee does not seem to be a successful crop among the small farmers. Lack of knowledge and extension services is a problem. Further, irrigation is necessary from mid May to the end of October (Mansfield 1973, Haandiya 1980). This is difficult to overcome for many peasants. Haandiya (1980) also states that coffee trees need a lot of nitrogen and other nutrients, lime and chemical spraying for growing satisfactory and yielding well. (Experienced at Kateshi coffee plantation, Northern Province.)

Other limitations for coffee growing among the small subsistence farmers will be the same as for sunflower and soya beans.

Plant characteristics and ecology

Ideal conditions for coffee cultivation are temperatures within limits of 16 - 25 C, well distributed rainfall, approximately 1900 mm a year, with the exception of a 2 - 3 month day period to ensure the initiation of flowering and further deep, tree drained soils which might be slightly acidic.

Coffee is usually propogated by seed selected from high yielding trees. Seedlings are bred in nursery beds, and planted when they are 12 - 13 months old. First light crop is produced less than two years after planting (Haandiya 1980). Pruning is necessary to ensure bearing.
Harvesting takes place several times during the ripening period, because it is essential only to pick uniformely ripe cherries. Coffee growing might impoverish the soil. That is the main reason for the importance of mulching in coffee cultivation. Other reasons for mulching are conserving the moisture, suppressing weed growth and preventing erosion. The average yield of pure coffee

is about 630 kg/ha; good management should produce regular yields of about 1250 kg/ha (Acland 1973).

Coffee projects and research work in Northern Province

Two big coffee projects have been undertaken with the help of the World Bank, Kateshi Coffee Plantantion and Ngoli RUCOM estates. 450 ha of land is available at Kateshi, where as about 110 ha planted today (Haandiya 1980). In addition, small holdings are established in Mpika, Mbala, Chinsali and at Misamfu R.R.S. Several coffee trials are going on; a long term fertilizer trial, variety trials, disease control investigations, irrigation trials, spacing observations and pruning trials.

Future aspects

From the Soil Productivity Research Programme point of view it is proposed that the coffee crop should be included in the agroforestry research programme.

8.17 Other crops

Tea (Camelli asinensis) Tea is not easy to grow well in the Northern Province (Mansfield 1973). However, a tea plantation has been established in Luapula Province.

Tobacco (Nicotiana tabacum). The climatic conditions in the province is not favourable for tobacco growing, mainly because of deficit in sunhours and the risk for dry spells during the rainy season (Mansfield et al. 1975). Despite this some production occurs. see Tables 7 and 8.

Sugarcane (Saccharum spp.). Sugarcane is not suited for cultivation in the Northern Province (Mansfield et al. 1975).

Cotton (Gossypium hirsutum). Mansfield et al. (1975) do not recommend cotton growing in the province. According to Tables 7 and 8 some production takes place.

Oil palms (Elais guineensis). Few oil palms are grown in the Northern Province, some are to be found on the Kilwa Island in Lake Mweru (Luapula Province). Peters (1948) suggests oil palm-production in the Mweru/Luapula/Bangwelu region. Mansfield et al. (1975) claim that oil palm is not suited for growing in the province.

Potato (Solanum tuberosum) (= European, Irish, English or Solanum Potatoes). A seed potato project has been proceeded at Uningi Pans, Mbala, but had to close down because of disease damage. Rainfed potato is strongly attacked by disease.

8.18 Indigenous leaf vegetables

In Zambia a number of indigenous plants are used as vegetables in the common diet. Many of them are wild plants generally growing as weeds, protected weeds or semi-cultivated weeds. Some are also regularly cultivated.

Among these the leaf vegetables play an important role. Many of them are available at the markets during the rainy season, some also during the dry season, fresh or dried. Leaf vegetables are often by-products of crops grown mainly for their fruits (e.g. beans, okra, cowpeas, pumpkins) and roots (e.g. cassava, sweet potato, cocoyams). Their advantages are that they are early, highly productive and the cheapest source of basic nutrients. Further, they are well adapted to local conditions, easy to grow and generally free from major pests and diseases.

Their main disadvantages are lack of improved seed, low yield per area unit, time-consuming picking, short storage capacity of fresh leaves, low social prestige and lack of knowledge of their nutritional value among the public.

They tend to rich in genetic diversity, and tend to have the greatest potential for improvement per unit of available resources devoted to assembling and utilizing their germplasm (IITA 1978).

Research work

Lewis (1972) carried out a survey of the useful wild plants of Zambia including the green leaf relishes. She also made a herbarium including 50 species identified as green leaf vegetables. Her survey covered most of Zambia, but could not include much detail for each area.

Epenhuijsen (1973) conducted a survey of local vegetables in use a relish in the Copperbelt towns as part of the vegetable improvement programme sponsored by FAO for the Copperbelt Province. This report contains a list of 20 species of plants sold as relishes in the Copperbelt markets.

Verboom (1973) compiled information on common weeds including information on the ones used as relishes.

At The National Irrigation Research Station (NIRS), Mazabuka, research on local types of rape, amaranths and cat's whiskers (Cleome gynandra) has started recently.

Rape (Brassica napus). This is a very popular vegetable in Zambia and provides plentiful green leaves a long period.

It has not received much attention until recently. Both local and exotic cultivars are now tested. The local cultivars have performed best so far and are suitable for seed production. Very few of the exotic cultivars produce viable seeds in Zambia. Rape does well during the winter season (June-July). During the rainy season blackrot (Xanthomonas) is a problem. There is not much hope of finding resistant cultivars.

Cvs. "NIRS-1" and "Great Essex" are superior for the wet season. During the hot season (August-October) diamond back moth (Plutella maculipennis) is a problem (Vegetable Research Team 1981).

Amaranths = African spinash (Amaranthus hybridus) is very high in nutritive value. It is very palatable, has wide adaptability and is easy to cultivate. It is a popular semi-cultivated vegetable in Zambia. Nevertheless, the local types are of poor edible quality and high in oxalic acid content. The acid reduces intake of calcium. Many improved cultivars are grown in other countries. Four local selections and five elite entries were included in the research at NIRS in 1980. Leaf yield, nutritive value and palatability (including oxalic acid content) were tested. One of the cultivars is also suitable for grain production. Two cultivars will soon be released on the market (Kurup, K. A., pers.comm.).

Cat's whiskers = Cleome (Cleome gynandra, Syn: Gynandropsis gynandra) is a local semi-cultivated leaf vegetable in Zambia. There is a considerable range in leaf size of plants in different parts of the country, perhaps due to human selection for large leaf size in some populations and not others (Lewis 1972). At NIRS seeds have been collected to identify types that could be introduced for cultivation, particularly in home gardens. Development of pure lines to release distinct cultivars is now in progress (Vegetable Research Committee Meeting 1982).

8.19 Other vegetables

Research work

In 1978 a vegetable research programme started with the main objectives of identifying improved cultivars of vegetables and developing appropriate agronomic practices for major vegetable crops. Most of the research is done at The National Irrigation

Research Station (NIRS) (Vegetable Research Team 1981).
Cultivar testing and selection is done for the following crops: Rape, kale, cabbage, amaranths, cleome, onions, tomatoes, chillies, sweet pepper, okra, pumpkins, watermelon, musk melon, beans, peas and carrots. This year eggplant will also be included (for export market).

Fertilizer trials have so far been done for cabbage, rape, tomatoes, potatoes and onions. These are mainly NPK trials.

The next step after the selection of cultivars, is to start management trials. This includes finding the best agronomy practices for seed production of certain vegetables. The aim is to produce pre-basic or breeder's seeds for selected vegetables and thus to supply Zamseed with the necessary material for seed production in Zambia. Seed production is easy for beans, peas and okra. Seed production for tomatoes and melons started last season (1981/82).

Pest and disease studies with emphasis on biological control and selection of tolerant or resistant cultivars, especially on Brassica spp., have now started.

Cabbage (Brassica oleracea var. capitata). Cultivars are tested for yield and resistance to black rot. Hybrid cultivars are also included. Cabbage does not produce seeds in Zambia.

Onions (Allium cepa). Cultivar testing has shown that white and yellow cultivars give higher yields and larger bulbs than the red cultivars. The red types have better storage quality, but this is not a major problem. Management trials for seed production are about to start. Cultural practices are the main constraint for wet season production because onions cannot tolerate water-logging.
'Texas Early Grano 502' and 'Tropical Ace' are two of the best cultivars.

Onions perform poorly on acid soils and phosphorous deficiency may cause growth stagnation (Ballvoll and Bjelland 1976).

Tomatoes (Lycopersicon esculentum). Early blight (Septoria solani) and blight (Phytophthora infestans) are causing problems particularly during the rainy season. Some resistance against early blight exists, but is not very effecient. They are trying to screen varieties for three seasons, but the possibilities are limited. No cultivars have been significantly better than the standard, 'Moneymaker', during the wet season. 'Rofarto VFN RS' is the best processing variety. 'Velox' exceeded other cultivars in yield in the winter season (Vegetable Research Team 1981).

Okra (Hibiscus esculentus). Early cultivars for export and long-term picking cultivars for home garden are selected. Both local and exotic selections are used. The local selections are generally indeterminate in growth habit and tend to continue fruit bearing for a longer periopd than the exotic cultivars. The fruit yields are low, however, and they are primarily grown for the leaves.
Okra grows well on acid soils.

Kale (Brassica oleracea var. acephala) is a leaf vegetable similar to rape and popular in Zambia. New exotic cultivars are tested against the standard 'Choumoullier'.

Export-trials. There are certain vegetables that offer good export potential, grown during the off-season periods of some European countries. These crops are capsicums (hot pepper, paprika, bell pepper), egg plant and okra.

Vegetable production in Northern Province a case study

Holden (1983) accomplished a survey on vegetable production in the following areas: Chitoshi, Senga Hill, Nondo, Kasama and Kayambi. He selected two villages in each of these areas except Nondo, where only one was selected.

The aims for selection of areas and villages were to get a broad view of the vegetable production on the central plateau. Therefore emphasis was put on selecting villages representative for each area, but also on selecting villages with varying degrees of urbanization and extension services.

In each area he carried out the survey in two stages, on village level and on household level.

This is a summary of the findings. For detail informations see Holden (1983).

Crops

The number of crops grown by each household varies and in Table 24 is estimated how commonly various crops are grown.

Table 24. Estimated percentages of households growing various crops (Holden 1983))

Percentage of the interviewed households growing specified crops (90 households)	
90%	Cassava, maize, sweet potatoes, beans, pumpkins, edible gourds, Cleome, banana
60-90%	Finger millet, groundnuts, small cowpeas, large cowpeas, fibimbi cucumbers, chillies, mango
30-60%	Groundbeans, tomatoes, mankolobwe cucumbers, mankangala cucumbers, okra, local eggplant, white rape (chibanga nkonde), rape, cabbage, onion, Livingstone potato, sugar cane, tobacco, calabash gourd, guava, oranges
10-30%	Sorghum, peas, pigeon peas, Lima beans, watermelon, cocoyams, Irish potatoes, chipatuka, kale, mulembwe mafulanshi, tumeric, pawpaw, lemon
10%	Chinese cabbage, sesame, spinach, carrots, lettuce, sweet pepper, coffee, avocado, pineapple

The following crops showed a particularly uneven distribution in the area: Small cowpeas, large cowpeas, peas, fibimbi, mankolobwe and mankangala cucumbers, watermelon, tomato, rape, cabbage, chipatuka, sugar cane, Irish potatoes, Lima beans and pigeon peas.

Crops not estimated: "Cassava tree".

Most important and commonly used wild vegetable plants:
Amaranths (bondwe and mutaka), orchid tubers (chikanda), black nightshade (nsululu, nkwila), mulembwe plants: m. pimpa, m. pupwe, m. lusakasaka, m. matama, m. ikombwe, m. sololo. (Used by more than 50 per cent of the interviewed households.)

Agricultural production and productivity are low in the area. The production systems are chitemene shifting cultivation, semipermanent hoe cultivation and some small-scale irrigation farming during the dry season.

The vegetable crops are usually an integrated part of the production systems. Very few farmers have specialized in vegetable production and the production is mainly subsistence-oriented. Near Kasama some specialized vegetable growers are found. In Chitoshi, Senga Hill and Nondo many farmers had beans as the main source of cash income.

Main constraints for production

Table 25 gives a review of the various constraints faced by the interviewed households.

Table 25. Main constraints for vegetable production, exotic vegetables (Holden 1983)

Type of constraint	No. of households who mentioned the constraint	Remarks
1. Lack of seeds	42	Biggest problem in Chitoshi and Kayambi
2. Water supply	58	
Specified: Water problem	38	
Watering work	11	
Distance to dambo	7	
Poor rainfall	2	
3. Pests and diseases	46	
Lack of pesticides & fungicides	6	
4. Land	6	
Lack of land	4	
Bad soils	2	
5. Lack of fertilizer	9	
6. Labour	29	
7. Market	8	
8. Age	5	May be considered as a labour constraint
9. Other reasons	9	

Seeds. The farmers stated that they found it very difficult to get seeds of exotic vegetables. Often they had to go all the way to Kasama, Mbala or Nakonde to try to get them. Many have experienced that when they came to these towns, the seeds were lacking there too.

The seed quality is sometimes also bad. Sale of expired seeds has occurred. Many farmers have experienced bad germination rates both for non-expired and expired seeds. VAP has sometimes helped supplying vegetable seeds to some farmers in their areas, but this has not been done systematically.

Table 26 gives a review of the seed supply and seed demand for the most popular exotic vegetables, and beans and groundnuts for the households interviewed.

Table 26. Seed supply/seed demand (Holden 1983)

Crops	No. of households who have bought seeds this year or last year	No. who want to buy
Rape	39	31
Cabbage	30	25
Tomato	25	12
Onion	19	12
Kale	7	13
Chinese cabbage	6	4
Irish potato	2	6
Beans	17	5
Groundnuts	6	3

Bean and groundnut sees are usually bought locally.

Water supply

Only a limited number of farmers use irrigation furrows. Those growing vegetables during the dry seasom without using an irrigation furrow, use very labour-intensive methods instead. Usually they use buckets or calabashes and carry the water from streams. Such heavy work limits production. Dry season production of vegetables involves mainly exotic vegetables. Just a few households in the Kasama area grew local vegetables like Cleome, white rape (chibanga nkonde), pumpkins leaves, bean leaves and amaranths during the dry season.

Access to suitable land for vegetable production is an important constraint for many households. This is often closely linked with access to water-supply, e.g. distance to dambo.

In Chipomo near Kasama and Kaminsa in Kayambi; the village houses were so closely spaced that this limited the size of the village gardens.

Pests and diseases were a considerable problem on exotic vegetables, but usually not on indigenous vegetables. Holden (1983) observed heavy black rot attack on some cabbage fields where cabbage has been grown several times concecutively. Aphids were mentioned as a major pest by 12 households.

In Nondo, where the production of exotic vegetables was high, they were eager to get chemicals to fight the pests and diseases, but the chemicals were considered expensive and hard to obtain. Very few farmers used chemicals.

Fertilizing

Some use fertilizer on exotic vegetables. Some also fertilized beans, but in Nondo and Chitoshi people were reluctant to do this. They said it only gave leaf growth and the seed yield would decrease. Those who used basal dressing ('X' or 'D'compound) on beans, however, obtained higher yields.

The average yields are estimated at 2 - 4 bags/ha without use of fertilizer. One bag is approximately 90 kgs. With use of fertilizer the yield would increase to 6 - 8 bags/ha with some obtaining 10 bags/ha.
Fertilizer was not used on groundnuts. "Pops" were common problem throughout the area, particularly on permanent fields.

In the 6 selected VAP-villages the problem of getting fertilizer was much reduced because VAP helps with the transport and supply free fertilizer the first year.

Labour constraints

During the rains cultivation of land for beans and groundnuts is very labour-intensive and often limits the area cultivated.

Production of exotic vegetables during the rains is very limited because labour is needed for production of other crops (staples). Transport of products to the market is also often a heavy and time-consuming job.

As earlier stated, labour-requiring water supply limits the dry season cultivation of vegetables.

Market

Not many households, just some in Nondo and near Kasama, considered the market as a constraint.

Vegetable production in Northern Province - future aspects

The vegetable crops are usually an integrated part of the production systems. Very few farmers have specialized in vegetable production and the production is mainly subsistence-oriented. Near Kasama some specialized vegetable growers are found. In Chitoshi, Senga Hill and Nondo many farmers had beans as the main source of cash income.

Bean production is limited by

a. labour requirements for cultivation and planting
b. poor and acid soils
c. late start of the rains in some areas (Kayambi) and some years.. This results in only one crop of beans being grown instead of two
d. heavy rain causing flower drop
e. bad seed quality due to pests and diseases.

The potential for increased production should, however, be good.

The future for groundnuts seems to be more uncertain. The production cannot be increased without the introduction of lime, because of their susceptibility to Ca-deficiency.

Access to markets or market outlets is the major constraint for production of exotic vegetables during the dry season and also influences the choice of cash crops in the various areas. The diversity of crops is greater near Kasama. There is a market outlet for a more diversified production, but the total demand is rather limited and thus also is the income from vegetables as cash crops. Vegetable schemes cannot be sucessful unless they get cash payment for their produce.

Water-supply is a major constraint for many households when subsistence production of fresh vegetables during the dry season is concerned.

Seed supply is poor due to inadequate delivery systems which limit both subsistence and sale production of exotic vegetables, particularly in rural areas. Seeds of rape, cabbage, tomato, onion and kale are in greatest demand and there should be a continuous supply of these seeds to local NCU-depots.

The quality of the produce at the markets is generally poor. This could be improved by:

a. better handling
b. grading the produce before bringing it to the market
c. using better packing materials
d: using improved cultivars and techniques.

This again would lead to increased demand. It is seldom or never difficult to sell high quality produce which also can fetch higher prices.

For exotic vegetables a lot of research is carried out at NIRS and other places. Now it is mainly a matter of transferring the knowledge into practical work.

Indigenous vegetables are not important as cash crops although many types are regularly found at the markets. Most households produce them themselves during the rains. There is, however, a potential for sale production of these crops during the dry season when they are scarce. Improved cultivars of e.g. Cleome, amaranths and okra sahould then be made available.

According to Holden (1983) the possibilities for increased crop production within the survey area lie in:

Improved shifting systems:
Planting of fallow vegetation, e.g. of shrub legumes like pigeon peas. They are found in the area, but are not popular as food.

Change to other farming systems than chitemene:

a. Shorter fallow period, increased use of grass-compost (fundichila), use of lime (?) and fertilizer.
b. Systematic mixed cropping, intercropping, crop rotations, alley cropping (?).
c. Dambo cultivation and use of irrigation furrows during the dry season.
d. Planting of perennial crops such as bananas and fruit trees.
e. Improved plant material, particularly of local crops.
f. A LIMA-programme for village gardens (?).
g. Increased labour productivity and labour saving techniques.

9. CROP ROTATION

Crop rotation is an important factor for the maintenance of soil fertility. Mono-cropping might lead to increased pests and disease damage, accumulation of unilateral flora and fauna, growth retarding substances developed from the roots, lack of micro- and macro-nutrients, negative humus balance in the soils and unfavourable soil structure.

Crop rotation is of great importance in the Northern Province because of the unnutrient and acidic soils. This might contribute to lengthen the cropping period, without reducing the yield. Mansfield et al. (1975) suggest grass/pasture as a possible way in a regulated crop rotation system, where the cultivators keep cattle. Green manure crops can become valuable parts of a rotation system.

Tables 27 and 28 shows different crop rotation practices in the Chitemene and Grass mound system. In the Mambwe area, mostly maize, finger millet and beans are rotated, each crop is grown 2 - 3 years before changing. However, changing every year might prove to be superior to this practice. Also cassava and groundnuts could be included in a rotation system. Beans seem to be the crop best suited for growing late in the rotation system; just before a fallow period is needed.

Trapnell (1953) describes the crops being used in the Chitemene system:

<u>1st year chitemene:</u> Catch crops are planted before or immediately after the first rain in November/December. A considerable variety of minor crops are used, such as spaced maize, edible gourds, pumpkins, fibimbi and mankolobwe cucumbers, large, creeping cowpeas, Cleome gynendra (Lubanga), Dolichos and sometimes Lima beans. The cassava grown in the chitemene garden by the Lungu and many of the Bemba is planted as cuttings inserted at wide intervals among these catch crops. The finger millet is broadcasted when the catch crops have sprouted.

<u>2nd year:</u> Groundnuts planted on flat land is the main crop. Groundbeans, large creeping cowpeas, small erect cowpeas and makolobwe cucumbers are sometimes included. Among the Namwanga and Iwa sesame is also grown among the groundnuts.

<u>3rd and later years: Fifwani fields:</u> Beans on mounds is the

Table 27. Different Rotation Systems in Chitemene-cultivation

Area / Year	Near Kasama	Near Kasama	Makasa				Chitoshi	Senga Hill/ Nono	Mwenesama
1. year	F.millet	F.millet	F.millet	F.millet	F.millet	F.millet	F.millet maize cassava	F.millet maize	F.millet cassava
2. year	Sorghum	Sorghum	F.millet	G.nuts	G.nuts	F.millet	Beans	G.nuts	G.nuts
3. year	Sorghum	F.millet	Beans or sorghum	Beans	F.millet	Beans	Beans	Beans	Beans
4. year	F.millet	Sorghum	Beans or F	Beans or F	Beans	Beans	Beans	Beans	Beans
5. year	Sweet potato	Beans	F	F	F	F	Beans	F	Beans or F
6. year	Sorghum	F	F	F	F	F	Beans or F	F	Beans or F
7. year	F	F	F	F	F	F	Beans or F	F	F
8. year	F	F	F	F	F	F	Beans or F	F	F
9. year	F	F	F	F	F	F	F	F	F
	Ricgards (1961)			Trapnell (1953)			Eriksen (1980)	SPRP (1981)	

F.millet = Finger millet, G.nuts = Groundnuts, F = Fallow

Table 28. Different Rotation Systems in the Mambwe Area (Grass mound system)

1. year	F.millet	F.millet	F.millet	Beans	Maize	Maize	Maize	Maize
2. year	F.millet	F.millet	F.millet	Beans	Maize	Maize	Maize	Maize
3. year	Beans	Maize	F.millet	Beans	Maize	Maize	Maize	Maize
4. year	Beans	Maize	F.millet	F.millet	Maize	Maize	Beans	Beans
5. year	Maize	Maize	F	F.millet	Maize	F	Beans	F
6. year	Maize	Maize	F	F.millet	F	F	Beans	F
7. year	F	F	F	Maize	F	F	Cassava	F
8. year	F	F	F	Maize	F	Beans	Cassava	F
9. year	F	F	F	Maize	F.millet	Beans	Cassava	F
10. year	F	F	Beans	F	F.millet	F	Cassava	Maize
11. year	F	F	Beans	F	F.millet	F	F	Maize
12. year	F.millet	Beans	F	F	Beans	F	F	Maize
13. year	F.millet	F.millet	F	F	Beans	F	F	Beans
14. year	Beans	F.millet	F	F	F	F	F	F
15. year	Beans	Maize	F	Beans	F	Maize	Maize	F
16. year	Maize	Maize	F	Beans	F	Maize	Maize	F

F.millet = Finger millet
F = Fallow

dominating crop. Maize, cowpeas and a few edible gourds, or occasionally pumpkins or mankolobwe cucumbers, are also included in some Bemba and Lungu "gardens". Some plants of local eggplants (Memba: Impwa) may be included. Early beans are commonly followed by a further bean crop planted without the addition of minor crops. Small cowpeas may also be planted after reaping of early millet.

Future aspects

To restore and improve soil fertility in Northern Province agriculture areas are of very much importance. No doubt, rotational systems including gramineous, legumineous and tree species can to some extent contribute to a better soil fertility situation. These type of research projects should get a high priority in the Soil Productivity Research Programme.

10. MIXED CROPPING

Mixed cropping is defined as at least two crops grown together on the same field at the same time. Mixed cropping is common in the Northern Province, for example:

- finger millet and cassava
- finger millet, bulrush millet and/or sorghum
- maize, cassava and/or finger millet
- maize and beans
- finger millet, cassava and groundnuts.

Okiybo and Greenland (1976) list some advantages of mixed cropping practice:

a) higher total yields and greater returns than the same crops grown in pure culture
b) increased erosion protection
c) insurance against crop failure

d) labour and harvesting are spread more evenly during the cropping season and storage problems may be minimized
e) locations are found for crops required in small quantities (for a range of products), and facilitates production of many crops in a limited area
f) it results in efficient utilization of resources by plants of different height, rooting systems, and nutrient requirements
g) where legumes are grown, other crops may benefit from the nitrogen fixed by the companion crop
h) diseases and pests do not spread so rapidly in mixed culture as in pure culture since all crops involved are not susceptible to the same extent.

Disadvantages of mixed cropping include:

a) mechanization planting and harvesting is difficult
b) it is more difficult to apply improved inputs e.g. fertilizers and herbicides
c) experimentation with intercropping is more complex and difficult to manage than sole cropping.

Research work

In 1976 a research programme in mixed cropping was undertaken in Zambia: "The Intercropping Research Programme". The programme was directed from National Irrigation Research Station (NIRS) at Mazabuka, and included:

a) Investigate the advantages of traditional intercropping systems in Zambia.
b) Test different cultures and varieties to try and find high-yielding combinations.
c) Investigate the utilization of nutrients, moisture and light by different crops.
d) Explain the results obtained with multi-cropping.

Table 29. Intercropping between maize and beans, effect on yield. (Research Branch 1978). Yield in kg/ha

	Maize		Beans	
maize	4460		1240	Beans
2/3 maize+1/3 beans	5400	+	1180	1/3 beans+2/3 maize
1/3 maize+2/3 beans	4720	+	1420	2/3 beans+1/3 maize

Table 29 shows that maize and beans grown in mixed stand give considerably higher total yields than grown in pure stand, 6580 kg/ha in average total yield contra 4460 kg/ha maize and 1240 kg/ha beans from pure stand plots.

Trials with sorghum at NIRS have resulted in:

a) 4205 kg/ha pure stand

b) 4527 kg/ha mixed stand

Sorghum yields following this, 322 kg/ha more in mixed stand than in pure stand.

Maize and groundnuts mixed is the combination which has proved highest yield-increase compared to separate cultivation. Best results were obtained when groundnuts were planted three weeks earlier than maize; yields increased up to 360% (Research Branch 1978).

Further research work is needed to make conclusions about best suited crop combinations, optimal cultivation techniques etc. Okiybo and Greenland (1976) say that appropriate equipment is being developed for mixed cropping purposes; both manual and mechanical.

Future aspects

Mixed cropping research results obtained in Northern Province are too few to be able to draw safe conclusions. It is therefore recommended to continue these investigations. The Soil Productivity Research Programme should take part in the Intercropping Research Programme.

11. LIVESTOCK - GRASS/PASTURE

Cattle

Total herd in the Northern Province in 1979 was 85,600. This was 3,500 less than in 1978 (Northern Province An.Rep. 1979). Traditional land use systems which include cattle (see Fig. 4).

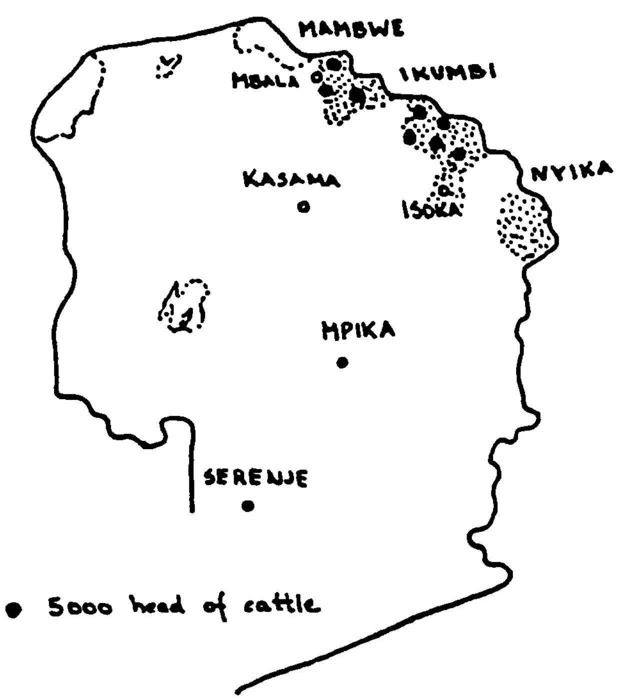


Fig. 4. Distribution of traditional owned cattle in Northern Province. (Schultz 1976)

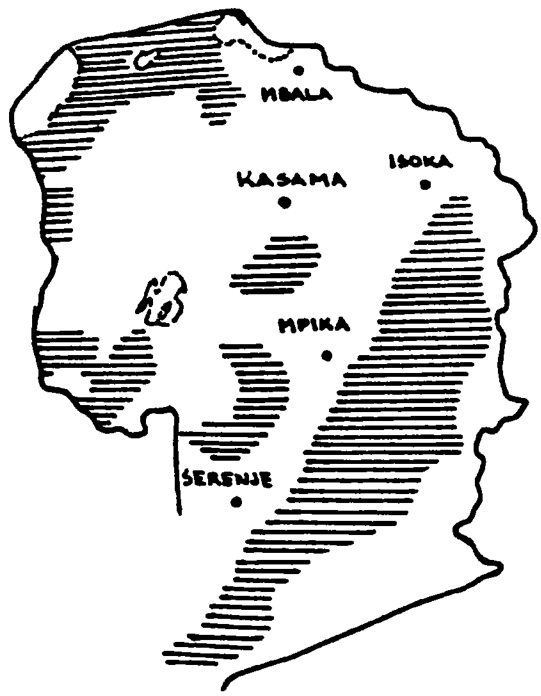


Fig. 5. Tsetse-infested area. (Schultz 1976)

1) Isoka system

The system combines Large circle chitemene and cattle raising. Half of the farmers keep cattle, on the average 20 animals each. The area under cultivation per holdings is on average 3.7 hectare, which is quite high according to traditional land use systems in Zambia (Schultz 1976.)

2) Mambwe system
(See chap. 4).

3) Ikumbi system
The Ikumbi system is in many respects similar to the Mambwe system. However, the mean acreage under cultivation per holding is noticeably greater. The system has developed from the Large circle chitemene system. Population pressure ultimately caused a breakdown of this shifting cultivation system. Today, cultivation on mounds and grass-composting are practiced. 13% of the holdings keep cattle, on average 12 animals each. Coffee has been grown by small farmers in this region since the early 1950's, without irrigation (Schultz 1976).

4) Nyika system
The Nyika system is also in many respects similar to the Mambwe system. In addition to semi-permanent maize fields and grass composting, the households have one or more large circle chitemene fields. 21% of the holdings keep cattle, on average 25 animals each (Schultz 1976).

Isoka, Ikumbi and Nyika system may be regarded as combinations and intermediates between the two main traditional land use systems in the province, Large circle chitemene and the Mambwe system. These systems are of little importance when it comes to distribution and land usage. Fig. 4 shows that traditionally owned cattle is little widespread in Northern Province.

Cattle are an important factor in crop-farming as cattle both provide manure and draught power for ploughing and transport. The possibilities for introducing/increasing the cattle keeping in the Northern Province is limited by:

a) The Tsetse fly. On third of the Luapula and Northern Provinces is Tsetse infected area (Fig. 5).
b) Tick and tick born diseases.
c) Deficiency in dry season grazing possibilities.

d) The dambo grass is often sour and of poor palatability for grazing during the dry period.
e) The soil is too unfertile for the cultivation of more high-yielding grass species without applying fertilizer. The natural grass species yield very low.
f) Clearing of woodland for pasture purposes may lead to destruction of the top soil structure (in the rainy season).
g) Regeneration of woodland after grazing may become a problem.
h) Lack of necessary services such as diptanks, veterinary help, extension, credit and efficient distribution facilities.
i) Lack of pastoral traditions (Mansfield et al. 1975).

In spite of these marks, it may as well be right to try to increase the cattle holdings in the province. Therefore, the pasture basis will be further described.

Grass production - pasture

Supplementary feeding among the traditional herd is not practised. The cattle are grazed on natural bush grazing in the wet season, and reliance is placed largely upon dambo or flood plains grazing in the dry season. The State Ranches usually provide maize bran and protein supplementary licks during the year (Northern Province An.Rep. 1979). The rainfall condition in the province is favourable for grass production. Several natural pasture species, which are satisfactory palatable, exist. Considering the pasture potential, over-grazing should not become a problem (Mansfield et al. 1975). Improvement of the natural grassland is possible by oversowing with legumes. This will increase the yield, the nutritional value and the palatability of the grass.

Recommen dations for grass-pasture cultivation

Recommended grass species are Rhodes grass (Chloris gayana) and Star grass (Cynodon nlemfuensis/C. aethiopicus/C. pectostachyus) and of legumes: Stylosanthes guyanemis/S. gracilis, Glycine wrightii and Macroptilium atropurpureum /Phaseolus atropurpureuas (Sirato). The Rhodes grass varieties which are best suited in Zambia are Zambian Commercial, Mpwapwa, Pioneer and Callide. Fertilizer application should be 300-600 kg/ha 'D'C'-comp, and 150 kg/ha Am.Nit. in the etablishment year; later 200-300 kg/ha 'D'C'-comp. and 150 kg/ha Am.Nit. as annual maintenance. If irrigation is used, it is possible to obtain 45-55 tons total dry matter per hectare. Rhodes is an ideal grass as a temporary 3 - 4 year lay in an arable rotation. The grass provides good first season grazing, yields tend to fall after the second year. Star grass is a good choice for a permanent pasture (McPhillips 1979).

Research work

Table 30. Fertilizer trial with Star- and Rhodesgrass

	Rhodes grass			Star grass		
Nitrogen kg/ha	P_2O_5 0 kg/ha	P_2O_5 45 kg/ha	Mean	P_2O_5 0 kg/ha	P_2O_5 45 kg/ha	Mean
0	3115	3202	3158	2328	3448	2888
34	3940	5027	4483	3796	4037	3917
67	5511	5369	5441	4953	5028	4991
101	5554	6142	5849	6838	8092	7466
Mean	4530	4935		4479	5151	
LSD at 5%	1723					

Table 30 shows a large yield response by Rhodes grass and Star grass to nitrogen. Nitrogen at the rate of 101 kg/ha and phosphate at the rate of 45 kg/ha give a mean dry yield increase of 5764 kg/ha for Star grass and 3027 kg/ha for Rhodes grass. Yields are obtained from two cuts, one taken on the 12th January and the second on the 16th May.

In 1966 six legumes were selected for observation at Misamfu RRS both for their palatability and their ability to grow under low fertility conditions. In 1967-68 they were grazed at monthly intervals and their reaction to grazing noted. The results were as follows:

- Tephrosia spp. (M 15 and M 16) and Indigotera spp. (M 12) were discarded because of no regrowth after grazing.
- Siratro (Phaseolus atropurpureus/Macroptilium atropurpureum): Few leaves were produced at the end of rains and little fodder was available during the dry season.
- Stylosanthes humulis annual: No regrowth after grazing.
- Stylosanthes guyanensis grew quickly and produced an upright mat of herbage mid May. It was not palatable enough to be grazed before that time. The regrowth after grazing was good. In mid August 3363 kg/ha dry matter was still left to be grazed; containing 12-15% crude protein. This legume was by far the most promising of those tested. The fact that it was not palatable during the period of maximum grass production makes it a good complement to grass (Mansfield 1973).

Table 31. Combined data yields for veld oversown with a legume. Unwin Moffat sub-station, Mbala 1967/68 (Mansfield 1973).
Four cutting treatments, dry matter yield in kg/ha

	Cutting treatment				
	1x	2x	3x	4x	Mean
Veld	3414	3138	3599	2312	3116
Veld/legume	5269	5607	5501	4296	5168
Diffenrence	1855	2469	1902	1984	2052
LSD at 5% level 1732 kg/ha					

Veld = Brachiaria nigropedata, Legumes = Stylosanthes guyanensis
1 cutting: June. 2 cuttings: February and june,
3 cuttings: January, April and June, 4 cuttings: December, February. April and June.

From the results in Table 31 it is seen that in all cutting treatments the veld/legume out-yielded veld alone significantly, but there was no significant difference between cutting treatments for either veld or veld oversown with legume. The overall mean increase due to oversowing with a legume was 65%.

In Zambia today, priority is given to investigate the value of legume components oversown on natural grassland and established pasture. Several trials show that legumes increase yield (Craufurd 1978b). Rensbury (1969) claims that the increase is due to a combination of two factors:

a) Additional herbage produced by the legumes. Legume establishment increases the total herbage production.
b) More vigorous grass growth due to nitrogen fixation by the planted legumes. Trials indicate that the grasses on grass/legume sites grow more vigorously and remain green much longer than where no legumes are established.

Mansfield (1973) does not agree that nitrogen fixation increases the grass growth. He is of the opinion that there are other factors which influence the growth in a possible way.

Natural "browse" plants in the Northern Province

Baphia bequartii (legume)
Uapaca nitida
Brachystegia speciformis (legume)
Isoberlinia anglolensis (legume)
Parinaria auretellifolia
Jubelnardia globiflora (legume)
Brachystegia florikunda (legume)
Diplorhynchus condylocarpon
Brachystegia utilis (legume)

The percentage of trees browsed at different times in relation to the total number of trees available from that species has been investigated. The results show: 100% of available Baphia bequaertii was browsed, 75% of available Parinari auretellifolia, 50% of available Uapaca nitida, Brachystegia speciformis and Isoberlinia anglolensis, and 10% of available Jubelnardia globiflora was browsed. The investigation was undertaken in May - June 1969 (Mansfield 1973).

The possibilities for cattlekeeping in the Northern Province

It may be of great importance for the small peasant households if oxen were made available for them, specially considering their labour and capacity situation. If cattle introduction is to become a success, it depends upon the etablishment of veterinary services, diptanks, extension etc.

Further research work is needed to investigate the natural and cultivated pasture potential, fertilizer response in natural grassland, oversowings with legumes, carrying capacity, regrowth after grazing, competition conditions between palatable and less palatable species, grass/pasture as a part of a rotation system, the possibilities for improving the dambograss in the dry season and the possabilities for using finger millet straw as subsidary fodder in the dry season.

Priority should be given to investigate upon better utilization of the natural grassland, since this is a resource available for everybody. Such investigations are for the present not considered as part of the Soil Productivity Research Programme.

In Tsetse infested area, there is a possibility to introduce Tsetse tolerante cattle from West-Africa, or use other animals than cattle (Mansfield et al. 1975). Another problem is tickborn diseases. Vaccinating and veterinary services may more or less control this problem. It seems like pastures, pests and diseases are not the limiting factor on cattle holding today. More important is the lack of pastoral traditions, and the lack of capital to obtain cattle.

12. POSSIBLE WAYS OF MAINTAINING THE SOIL FERTILITY AND INCREASING THE SOIL PRODUCTIVITY IN NORTHERN PROVINCE

Experiments described in Chapter I and Chapter II indicate that fertilizer application increases the yield in the short term, but after some years with continuous cropping the yield decreases drastically. Dumont (1979) claims that chemical fertilizer replaces local sources of manure, allowing permanent cultivation without organic manure which destroys the soil structure and exhausts the soil. It would be of great importance to find alternative manure methods which maintain yield better than artificial fertilizer does, and also preserve the soil structure and fertility better. See Mansfield et al. 1975.)

Other conditions which limit the use of commercial fertilizer in Zambia are:

a) Fertilizer is rarely available for the small peasant households, due to lack of credit facilities, distribution, etc. (See Stølen and Archetti 1981 and Vedeld 1981).

b) Zambia uses valuable foreign currency on importing expensive fertilizers. In 1978 the country imported 140,000 tons of fertilizers (McPhillips and Prior 1979).

c) Using fertilizer, the peasants become dependent on supply from the outside, which has proved to be poor and difficult to rely on. The peasants themselves have no possibility to affect the supply situation (Eriksen 1980).

d) Modern cultivation with the use of fertilizer is often more labour requiring than the traditional agriculture (Mansfield 1973 and 1974).

e) Fertilizer use increases the soil acidity (Greenland 1975).

If the use of fertilizer is to become more widespread in the Northern Province, it is important to improve the credit facilities and the supply situation; further to develop a fertilizer-practice which does not destroy the soil structure and exhaust the soil. Possible soil improving methods may be liming, green manuring, live mulch cropping systems, alley cropping and agroforestry. The latters will be further described in the following. For the Soil Productivity Research Programme it is highly recommended to include this in its programme.

12.1 Green manure

To plow down or hoe into the soil a quick growing leafy crop, usually a legume, before cultivating, is called green manuring. This maintains organic matter in the soil. The soil matter is important for instance the soil fertility and exchangeable cations. Using legumes, an additional boost to the soil nitrogen supply is obtained. Concerning physical terms, the structure is improved by the green manure.

Green manure systems may give satisfactory yields during a long period without adding fertilizers (Hartmans 1981). A disadvantage is that the system involves high labour requirement. Other less labor consuming systems with similar positive effects is live crop mulching systems and alley cropping.

12.2 Live mulch cropping system

Live mulch cropping system is a crop production technique in which food crops are planted directly in a living cover of a low growing plant (legumes or grasses) with a minimum of soil disturbance. The system incorporates soil conservation features of organic mulch and no tillage, but has the advantage of smothering weeds. The legume live mulch contribute nitrogen to the system (IITA Research highlights 1979).

Live Mulch Cropping System is less labour consuming than green manuring techniques, and the cropping might start earlier in the growing season.

Lal (1974) claims that the advantages of this system of land management are:

a) Steady yield returns over a long period
b) Soil erosion and run-off control
c) Increased soil moisture storage capacity
d) Reduced soil temperature variations
e) Soil structure maintance
f) Savings in time (seed bed preparation, tillage, and weed control)
g) Requirement for fertilizer can be minimized
h) Fertilizer efficiency (less loss of fertilizer elements in the run-off water).

Encouraging experimental results of the effect of live mulch on crop yields have been obtained. Yield was significantly higher in live mulch plots that did not receive any fertilizer than in similarly treated base and conventional tillage plots. When fertilizer was applied to both live mulch and bare plots, yield in live mulch plots was either better or as good as the yield from base and conventional tillage plots (Hartmans 1981).

<u>The effect of cover crop cultivation on the soil</u>
In addition to the green manuring effect of the cover crop, live mulch cropping system acts as a protecting cover which influences the soil physical properties in a positive direction (Lal 1974).

<u>Erosion control</u>: Mulching has a distinct advantage for erosion control on tropical soils. Not only is the raindrops' direct impact on the soil avoided by mulching; the runoff losses also are minimized because the soil infiltrability is maintained at its maximum level.

<u>Soil temperature</u>: The temperature variation in the soil situated under a mulched layer is reduced. In a tropical climate, mulch keeps the soil temperature more uniform and decreases the amplitude of temperature waves. Temperature differences of as much as $8^{o}C$, were observed at IITA, between mulched and unmulched plots at 5 cm depth.

Soil moisture: Mulching generally improves the soil moisture conditions as losses caused by surface runoff and evaporation are decreased (Lal 1974).

Soil structure: Mulching affects the soil structure and porosity both directly and indirectly. By minimizing the direct impact of raindrops, there is a minimal crustation and therefore the initial pore space is maintained. Indirectly, mulching influences the activity of micro flora and fauna and hence the soil structure. Notably is the earthworm activity influenced by mulching that stimulate worm casting.

Live mulch covers as weed- and bush control

The need for weed control as a crop production input, can be eliminated in established live mulch covers. Results from IITA shows that crop yields in plots weeded at least three times were comparable to those in which weeds were controlled by the low growing crop "Egusi melon" (*Citrullus lanatus*), followed by sweat potatoes (*Impomea batatas*) after the melon had become senescent (IITA Research highlights 1979).

Bush residue management is a serious problem in areas where crops are grown in land freshly recovered from bush fallow. The common practice is to burn this residue. However, burning exposes the soil surface to rain drops and increases the potential for soil losses by erosion. The use of leguminous cover crops make residue burning unnecessary. The technique has been tested and found practical for cover crops as *Stylosanthes guianensis*, *Pueraria phaseoloides*, *Centrosema pubescuns*, *Calopogonium mucunoides* and *Psophocarpus palustris* (IITA Research highlights 1979).

12.3 Alley cropping

Alley cropping is a system in which arable crops are grown in the spaces between rows and planted woody shrubs or tree fallows. The fallow species are periodically cut down during the cropping season to prevent shading and provide green manure for the companion crop. The alley cropping system retains the basic features of bush fallow. It offers an attractive alternative and may be easily adopted by small farmers in tropical Africa (Hartmans 1981).

The major modifications are:

a) Selected species of fast growing small trees and shrubs (usually legumes with nitrogen fixing ability) are used to replace the naturally regenerated bush fallow.
b) The small trees or shrubs are planted with interriour spacing wide enough to allow for the use of mechanized equipment, e.g. 4-6 m.
c) Trees cut back and kept pruned during the cropping period. Leaves and twigs are applied to the soil as mulch and nutrient source. Bigger branches are used as stakes or firewood.
d) Cut-back height of trees/shrubs depends on the kind of crops grown in the field.
e) Plowing is sometimes used to cut tree roots in order to reduce competition with crops.
f) Trees can be planted along with crops to reduce cost of tree establishment.

Research work

Promising results have been obtained from alley cropping trials with maize and Leucaena leucocephala conducted at the IITA site in Ibadan. The use of Leucaena tops maintained maize grain yields at reasonable levels even with no nitrogen input on low fertility sandy soil.

Table 32 shows that the yield is doubled when Leucaena prunings are left to rot in the rows between the farm crops, compared to being removed. This is without application of fertilizer. Best yield results are obtained when both fertilizer and Leucaena prunnings are applied. The nitrogen contribution by Leucaena mulch on maize grain yield was equivalent to about 100 kg/ha for every 10/ha of fresh prunings (Hartmans 1981).

Table 32. Effect of application of nitrogen and Leucaena prunings on grain yield of maize grown in alley (Hartmans 1981). Yield in kg/ha

N-rates, kg/ha	Leucaena prunings	Main season	Minor season	Total
0-N	Removed	1036	754	1780
0-N	Retained	1918	1573	3491
40+30 N	Retained	2648	2310	4958
80+60 N	Retained	3258	2703	5961
LSD 5%		312	278	

(1) Main season maize received 40 and 80 kg N/ha. Minor season maize received 30 and 60 kg N/ha.

IITA Research Highlights (1979) summarizes the effects of alley cropping in the following way:

a. Recycling of the plant nutrients
b. Enriching the organic matter and nitrogen level of the soil
c. Reduction in run-off and soil erosion
d. Climbing crops are given support.

The system of continuous bush fallow as observed in alley cropping is expected to retain soil productivity for a long period and allows for more efficient use of the land.

12.4 Zero tillage or reduced tillage farming

Large scale mechanized farming schemes, based on methods of crop production from the temperate zones, have invariably failed in the tropics due to an inability to prevent erosion and to control weeds, further causing soil compaction, loss of soil fertility and structure and decreased water infiltration (IITA Research Highlights 1977). The production of crops without tillage seems to be a way of avoiding these problems more or less.

No-tillage is essentially farming without plowing, where seeds are planted in a narrow slit or trench opened mechanically in killed sod, previous crop residue or a cover crop. Weed and other competing vegetation are controlled by chemical herbicides, mechanical weeding with row weeders or hoes, or by live mulch covers.

In addition to the advantages of no-tillage on soil and yield, the economic benefits are:

a. The need for and investment in machinery is reduced.
b. Energy requirements are reduced.
c. The time required for land preparation is reduced.
(IITA, Research Highlights 1977)

Although no-tillage reduces the need for machinery and draught power, it is still important to develop appropriate equipments to carry out necessary operations. IITA has designed implements appropriate for small scale farmers. A manual rolling plant-machine sows the seed through crop residues with a minimum of soil disturbance (the rotary punch planter). Further, a ultra low volume sprayer (the Controlled Droplet Applicator) has been developed to apply herbicides. By using no-tillage farming and these two implements, the labour requirements might be reduced to 1/10 of traditional labour requirements (IITA Agriculture Engineering Programme 1978).

No-tillage farming and appropriate tools might be a way to reduce the need for manpower which today is an important constraint to increased production in the Northern Province. It is a system which requires small changes and investments compared to present technology, but nevertheless might lead to great improvements. The system does not include an introduction of oxen or tractors. Greenland (1975) claims that chemical herbicides is a better alternative than oxen/tractor introduction, because it is simple and cheap and therefore might reach the small farmers.

However, it may seem even better to develop an effective, labour saving, biological method of weed control, e.g. live mulch covers.

12.5 Agroforestry farming system

Agroforestry is a sustainable land management system which increases the overall yield of the land, combines the production of crops and forest plants on the same unit of land and applies management practices that are compatible with the cultural practices of the local population.

Apart of the objective of the project is to develop efficient agroforestry cropping systems that are suitable to the high rainfall areas. An important task will be to develop sound cropping patterns that allow for maximum conservation of soil moisture, efficient utilization of solar radiation and available nutrients from the soil. Experiments in intercropping trees with legumes, cereals, root crops in various combinations should be started. The following tree/crop combinations are suggested:

- Trees + Cereals + Grain legumes
  e.g. Brachystegia/Acacia albida + Maize/
  Wheat/Finger millet + Beans.
- Trees + Root crops + Cereals + Grain legumes
  e.g. Mango/Guava + Cassava/Sweet potato +
  Maize/Wheat/Finger millet + Beans.
- Trees + Legumes
  e.g. Cofffee + Leucaene esculenta + Beans.

In addition one should develop methods to improve and conserve soil resources under intensive agroforestry cropping, e.g. determining techniques of tillage (also minimum tillage), planting methods, crop protection techniques for control of pests, diseases and weeds and fertilizer application (rates, sources, timing, placement).

13. CROP GENETIC RESOURCES

There is no doubt that a key to better yields and more nutritious crops is provided by plant breeding and by the development of new crops tailored to the needs of the people concerned. Higher energy production (carbohydrate, fats) and better nutritive quality (proteins with the correct amino acid balance, vitamins, etc.) are needed. Furthermore, varieties that are better adapted to existing conditions, yielding well even though fertilizer applications are not high and able to withstand extremes of heat, cold, drought or soil acidity are being created by plant breeders in various countries. Utmost important is also breeding for resistance against fungal, viral and bacterial diseases and against insect and nematode pests.

In the interest of rapid agricultural development in the high rainfall areas it is very important to test new varieties of species with genetic characteristics adapted to soil and climatic conditions in the Northern parts of Zambia. It is therefore recommended to keep in contact with plant breeding centres which can support the project with new plant breeding materials.

14. CROPPING SYSTEMS

Research on the best methods of farming for a given area, having in mind soils, rainfall, farmers know how and technology and other factors may hopefully increase the level of farming efficiency, and thus contribute to the solution of the food problem.

It is becoming especially clear that improved traditional farming methods may be in the long run more efficient than standard methods imported by experts from other countries. Thus the use of mixtures of crops in the same field is now attracting considerable interest.

Research on mixed cropping systems has had and still has a low priority in Zambia's agricultural research programmes. It is, however, recommended that the SPRP agronomy section should take active part in the exsisting research mixed cropping projects. In addition SPRP should also develop its own experiments adapted to the high rainfall areas. Investigations should for example include:

- Plant population of the component crops.
- Length of the growing season.
- Plant structure (height, canopy structure, rooting system).
- Relative duration of the life cycle of the component crops.
- Nutrient requirements.
- Planting pattern.
- Soil fertility.

15. SUMMARY

Phase I of the Soil Productivity Research Programme comprises an evaluation of previous and exisiting farming systems in the high rainfall areas of Zambia, with regard to the small peasant households. This report is related to the agrotechnical part, with emphasis on traditional farming systems, crops and farning potential. The aim to give a realistic description of the crop husbandry in the province, elucidate the problems faced by the farmers, and to discuss strategies for cultivation which might decrease the fallow period and increase the crop production.

The traditional farming system which dominate in the Northern Province is a type of shifting axe and hoe cultivation, chitemene. Trees are lopped or cut, and the branches and the wood are piled up for burning in the middle of the originally cleared area. Cultivation is confined to the burnt patch, where the ash layer helps to overcome the inherently low soil fertility and the heat from the burning to control weed growth. The continuous use of the land extends over 3-6 years, followed by 20 - 30 years fallow.

The system is in some areas about to break down because of a slow degeneration of the forest and increasing population. Lack of suitable woodland leads to clearing of bigger areas and hence reduction of the fallow period, both which are making the degeneration of the forest more serious as time passes.

The Grass mound system is confined the the northern part of the province. The Mambwe people practise a distinct method of soil improvement by the means of incorporating grass and herbs into mounds. These plants then decompose to form compost. In addition they keep cattle and use ox-ploughing. In this area the population density is higher than in the chitemene area, and lack of land suitable for cropping might be a problem.

Constraints faced by the small peasant households:

1. Lack of capital, credit facilities and supply services result in applications, where cultivation is based on external factors.
2. Shortage of labour, appropriate tools, draught power etc. result in poor weed control, that harvesting starts late and takes too long time which again causes unnecessary grainloss, and that known methods for improving the soil becomes too labour demanding to practise.
3. A fallow period is necessary both in the Chitemene and Grass mound system. The yield decreases rapidly after some years with continuous cultivation also when fertilizer application is practised.
4. The extension service is insufficient and comprises modern farming methods based on implements that are not available for the small peasant households. Traditional crops are more or less neglected. The marketing situation is difficult, and e.g. finger millet and cassava is not purchased by the Northern Cooperative Union.

There are two different development strategies for the small peasant households in the Northern Province:

1. A more intensive system based on traditional crops and green-manure methods.
2. A conventional and modern farming system based on fertilizers, chemicals and cultivation of cash crops.

It is also possible to combine these two development strategies. At the time being, it seems like alternative 1 is best suited and most likely to succeed in improving the situation of the small peasant households. A more detailed strategy might be:

- Encouragement to increase the production of finger millet, cassava, groundnuts and beans.
- In addition fruit- and vegetable production and if the circumstances allows it maize and rice.
- High yielding and high quality protein varieties, that are disease and pest resistant.
- Crop rotation and/or mixed cropping.
- Legumes with highly active nitrogen-fixing rhizobia to supply nitrogen both to the soil and to other crops.
- Soil improvement: zero tillage and plant residue mulches, e.g. alley cropping including agroforestry, live mulch cropping systems and moundsmaking.
- Control of acidity by means of mulches of deep-rooted species or ash, or by lime and trace elements where lime is readily available.
- Fertilizers to replace the phosphorous and possibly other nutrients removed in produce sold "off the farm".
- Improvement of the labour situation: zero tillage, appropriate tools, if possible introduction of oxen, further to develop laboursaving harvesting methods.
- Weed control by means of single or double weeders and leguminous cover crops.

16. LITERATURE

Acland, J. D. 1971 and 1973. East African Crops. Longman Group Ltd., London.

Alder, J. 1958. Report of an investigation into Chitemene Control in Abercorn District. Dept. of Agriculture, Lusaka.

Allan, W. 1965 and 1967. The African Husbandman. Oliver and Boyd, Edinburgh and London. Barnes and Noble, New York.

Balvoll, G. & Bjelland, O. 1976. Grønnsakdyrking på friland. Landbruksforlaget, Oslo, Norway. p. 96.

Boer, de, H. G. 1978. Agricultural Research. North-Western Province, 197-77, Results and Recommendations. Dept. of Agriculture.

Boyd, W. J. R. 1959. A report on the Lunzuwa Agricultural Station. Its History, Its Development and Its Work. Misamfu Regional Research Station, Kasama.

Central Statistical Office 1970/71. Census of Agriculture. Lusaka (unpublished).

Central Statistical Office 1980. Census of Population and Housing. Preliminary Report. Lusaka.

CIMMYT - Purdue 1975. High Quality Maize. Dowden, Hutchison and Ross Inc. USA.

Craufurd, R. Q. 1978. Review of Rice Research 1967-1978. Research Memorandum No. 25. Dept. of Agriculture, Lusaka.

Craufurd, R. Q. 1978b. Pasture Grasses and Legumes Report on Plant Breeding at Mt. Makulu 1967-1978. Research Memorundum No. 26. Dept. of Agriculture, Lusaka.

Davies Hywell, D. 1971 and 1972. Zambia in Maps. University of London Press Ltd. England.

Department of Agriculture 1980. Programme of work and list of experiments 1980/81. Lusaka.

Dept. of Agric., 1979. Lima Crop Memo. Northern Province. Small scale farmer recommendations. Research Branch, Zambia. 21 pp.

Duke, J. A. 1981. Handbook of Legumes of World Economic Importance. Plenum Press, New York.

Dumont, R. 1979. Preliminary Report on Rural-Underdevelopment in Zambia.

Edou, O. 1977. Rice Production in Northern Province. Annual Report 1976/77. Dept. of Agriculture, Lusaka.

Epenhuijsen, C. W. von, 1973. Vegetable Research. Report to the Government of Zambia. NOTA 3231, FAO, Rome. 45 pp.

Eriksen, E. 1980. Village Agricultural Programme. Report. NORAD, Oslo.

FAO SOILS BULLETIN 24 1974. Shifting Cultivation and Soil Conservation in Africa, FAO, Rome.

Greenland, D. J. 1975. Bringing the Green Revolution to the shifting Cultivators. Science: 28.11.75. Vol. 190.

Grubben, G. J. H., Tindall, H. D. & Williams, J. T. 1977. Tropical vegetables and their genetic resources. International Board for Plant Genetic Resources, Rome. 197 pp.

Haandiya, B. H. 1980. Kateshi Coffee Plantation. Project No. 863 ZA. Kasama Project. Zambia.

Hansen, E. 1981. Jordbruksarbeid i u-land. Norkontakt No. 3/81, NORAD, Oslo, Norway, p. 53.

Hartmans, E. H. 1981. Land Development and Management in Tropical Africa. I.I.T.A. Ibadan.

Haug, R. 1981. Agricultural Crops and Cultivation Methods in The Northern Province of Zambia. Zambian SPRP Studies, Occasional Paper No. 1, IDP, Agric. Univ. Norway, Ås.

Heide, O. M. and O. Aresvik 1980. Report from a visit to Zambia. NLH-Ås.

Holden, S. T. 1983. A survey of the vegetable production and marketing of the central plateau in Northern Province, Zambia. Zambian SPRP Studies, Occasional Paper No. 5, IDP, Agric. Univ. Norway, Ås.

I.R.D.P. 1981. Intergrated Rural Development Project, Kasama. Personal message.

I.R.D.P. 1983. The dynamics of cropping patterns and maize production in Serenje, Mpika and Chinsali Districts. Proceedings of the seminar in soil productivity in the high rainfall areas of Zambia, Lusaka 8-14 February 1983. pp. 269-288. Zambian SPRP Studies. Occational Paper no. 6, IDP, Agric. Univ. Norway, Ås.

I.I.T.A., 1978. Crop genetic resources in Africa. Ibadan, Nigeria, p. 134.

I.I.T.A. Research Highlights 1977-1979, Ibadan, Nigeria.

Kurup, K. A. 1982. Horticultural Research Officer, NIRS. Pers. comm.

Lal, R. 1974. Role of Mulching Techniques in Tropical Soil and Water Management. Technical bulletin No. 1, I.I.T.A. Ibadan.

Lewis, G. 172. A preliminary collection of the useful wild plants of Zambia, Mt. Makula Research Station. 61 pp.

Mansfield, J. E. 1973. Summary of Agronomic Research Findings in Northern Province, Zambia. Land Resources Division, England.

Mansfield, J. E. 1974. Analysis of Data from sample farms and cooperatives in Northern and Luapula Provinces in Zambia. Vol. 1. Analysis. Ministry of Overseas Development, London.

Mansfield, J. E. et al. 1975. Land Resources of the Northern and Luapula Provinces, Zambia, a reconnaissance assessment. Vol. 1-4. Land Resources Division, England.

Marter, A. 1978. Cassava or Maize. RESB/UNZA, Lusaka.

McPhillis, J. K. 1976. Fertilizer recommendations and crop yields in Zambia. Dept. of Agriculture, Lusaka.

McPhillips, J. K. 1979. Crop Advisory Sheet. Dept. of Agriculture, Lusaka.

McPhillips, J. K. and A. J. Prior 1979. Introducing the LIMA. Dept. of Agriculture, Lusaka.

Melhuish, G. 1976. Review of field Bean Investigations 1969/70 - 1975/76. Cobberbelt R.R.S. Dept. of Agriculture, Lusaka.

Melhuish, G. C. 1978. Beans (Phaseolus vulgaris), review of agronomic investigations, 1969 - 1976. Research Memorandum No. 20. Research Branch, Dept. of Agric., Zambia. 57 pp.

Misamfu R.R.S. 1980. Annual Report 1979/80.

Northern Province Annual Report 1978/79. Dept. of Agriculture, Kasama.

Northon, G. 1978. Plant Protein. Butler and Tanner Ltd. London.

Okiybo, B. N. and D. J. Greenland 1976. Intercropping Systems in Tropical Africa. Reprints Series No. 96. I.I.T.A. Ibadan, Nigeria.

Onwueme, J. C. 1978. The Tropical Tuber Crops. John Wiley and sons Ltd.

Opsahl, B. 1980. Viktige vekster i verdens jordbruk. PKI. Ås-NLH.

Pearson, R. W. 1975. Soil acidity and liming in the humid tropics. Cornell University, Itacha, New York. 66 pp.

Peters, D. V. 1950. Land usage in Serenja District. Rhodes-Livingstone. Pap. No. 19.

Provincial Agricultural Officer (PAO) 1980. Annual Report 1978-79.

Purseglove, J. W. 1979. Tropical Crops. Dicotyledons. Longman, London, p. 306, 310.

Pexco-minutes, 1981. Misamfu R.R.S. Dept. of Agriculture.

Rensbury, van, H. J. 1969. Introduced Legumes in Natural grassland and in established pasture in Zambia. Dept. of Agriculture, Lusaka.

Research Branch 1977. Annual Report 1976/77/

Research Branch 1978. Annual Report 1977/78. Department of Agriculture, Lusaka.

Research Branch 1979. Lima Crop Memo. Northern Province. Department of Agriculture, Lusaka.

Richards, A. I. 1939, 1952 and 1961. Land, Labour and Diet in Northern Rhodesia. Oxford University Press and Amen House, London.

Sarmezey, A. A. V. 1978. Finger-millet, Review of Agronomy and Breeding 1960-77. Dept. of Agriculture, Lusaka.

Schultz, J. 1976. Land Use in Zambia. Afrika-studien. Welt-Vorum verlag, Munchen.

Shah, J. H. 1975. Inoculation of legume seeds. Farming in Zambia. Vol. 9, No. 1, p. 17.

Stølen, K. A. & Archetti, E. P. 1981. Preliminary report on socio-economic constraints in agricultural production in Northern Province, Zambia. Agricultural University of Norway, Ås. 43 pp.

Stølen, K. A. 1983. Peasants and Agricultural Change in Northern Zambia. Zambian SPRP Studies, Occasional Paper No. 1, IDP, Agricultural University of Norway, Ås.

Trapnell, C. G. 1953. The Soils, Vegetation and Agricultural systems of North-Eastern Rhodesia. Government Printer, Lusaka.

U-landsavdelingen, S.L.U. 1980. Nutrition och Lantbruk- om samspelet mellan människan, jordbruket och födan. Sveriges Lantbruksuniversitet, Uppsala.

Usher, G. 1974. A Dictionary of plants used by man. Constable and Company Ltd. London.

Uyole Agricultural Centre 1980 A. Agricultural Research Programme. p. 26-27.

Uyole Agricultural Centre 1980 B. Annual Report 75/76, Part 2. p. 120-121.

Vegetable Research Committee Meeting 1982. February 5, Mt. Makulu. Co-ordinators report, p.6.

Vegetable Research Team 1981. Third Annual Report. National Irrigation Research Station, Mazabuka. Dept. of Agric., Zambia. 112 pp.

Vedeld, T. 1981. Social-Economic and Ecological Constraints on Increased Productivity among Large Circle Chitemene Cultivars in Zambia. Zambian SPRP Studies, Occasional Paper no. 2, IDP, Agric. Inuv. Norway, Ås.

Vedeld, P. & Øygard, R. 1982. Peasant household resource allocation. Zambian SPRP studies, Occasional Paper no. 3, IDP, Agric. Univ. Norway, Ås. 145 pp.

Verboom, W. C. 1973. Common weeds of arable lands in Zambia. Min. of Rural Development, Lusaka. 130 pp.

Vikan, J. G. 1981. Personal message.

Vogt, J. B. M. 1965. Survey of the Results of some maize fertilizer experiments carried out in Zambia in the 1963/64 season. Research Memorandum, No. 2. Dept. of Agriculture, Lusaka.

Wall, J. S. and W. M. Ross 1970. Sorghum Production and Utilization. Avi p.c. USA.

Zam-Can 1980. Annual Research Report 1979/80. Zambian-Canadian Wheat Development Project, Mbala.

Zambian Government 1978. Third National Development Plan 1979-83. Government Printer, Lusaka.