Agricultural Technologies Released by the Ministry of Agriculture and Food Security-2000-2005

[Crop varieties, crop and livestock production technologies, and agricultural processing and utilization technologies]


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May 2006
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Ministry of Agriculture and Food Security:
2000-2005
[Crop varieties, crop and livestock production technologies, and agricultural processing and utilization technologies]

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Lilongwe, Malawi, May 2006
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Agricultural technologies in Malawi are developed by both public and private sector organizations. Technologies presented in this document have been developed by the following organizations: DARS, ARET, TRF, MRI, Bunda College of Agriculture, Chemical Input Suppliers (Chemicals and Marketing Company and Farmers’ Organization), Seed Production Companies (SeedCo Malawi Limited, Pannar, Pioneer, and Monsanto Malawi Limited). DARS, one of the seven technical departments in the Ministry of Agriculture and Food Security (MoAFS), is the main public sector organization that has developed most the technologies reported in this document.

Until 1998, only crop varieties, or crop cultivars, were officially released through the Variety Release Committee (VRC) of MoAFS. The released crop varieties are documented in a "A Description of Crop Varieties Grown in Malawi". Various updated versions of this booklet are available to Jill stakeholders in the agricultural sector.

Further, before 1998, there was no specific requirement that other agricultural technologies (such as crop and livestock production technologies) should equally be officially released by the VRC before they are disseminated to farming communities. Thus, it was also not required that the developed technologies should be systematically documented as the case was with crop varieties.

However, in 1998, MOAFS, through the Agricultural Research Council (ARE), made a cross-cutting recommendation that all agricultural technologies developed by different scientists in Malawi should be officially approved and released by the newly formed Agricultural Technology Clearing Committee (ATCC). The ATCC is a Ministry of Agriculture and Food Security committee that is chaired by the Controller of Agricultural Extension and Technical Services (CAETS), and DARS serves as its Secretariat. It was further recommended that all released agricultural technologies should formally be documented periodically.

Over the last six years (2000-2005), several agricultural technologies: (i) crop varieties, (ii) crop and livestock production technologies, and (iii) agricultural processing and utilization technologies, have been developed and released by the ATCC. These technologies are presented in this document.

I am, therefore, pleased to present to you this document that contains the latest information on new technologies that can be used by farmers to substantially increase crop and livestock productivity. I am very hopeful that you will find the information in this document useful and informative so as to make an informed choice of the technology you want to use. It is my sincere hope that the use of these technologies will significantly increase agricultural productivity in Malawi, thereby greatly contribute to governments policy objectives of ensuring food security, reducing poverty, and ensuring sustainable utilization of Malawi’s natural resources.

J.H. Luhanga
Controller of Agricultural Extension and Technical Services
One of the major challenges facing the Department of Agricultural Research Services (DARS) is the low adoption of new agricultural technologies by farming communities, especially smallholder farmers. There are many reasons for this, including lack of knowledge, know-how, skills and awareness and poverty. Lack of awareness is an endemic problem, especially among smallholder farmers that has significantly contributed to low adoption rates.

There are many ways of reaching out to stakeholders in the agricultural sector, including: (i) field days, (ii) workshops and public seminars, (iii) scientific conferences, joint meetings, (iv) on-station demonstrations and on-farm verification trials, and (v) print media (e.g., use of AgricTech News, extension circulars, posters, station flyers, station guides, scientific proceedings, annual reports, Research bulletins, and scientific journals). This document is one tool for disseminating such information on new agricultural technologies to various stakeholders in the agriculture sector, and enhancing technology transfer, adoption and utilization.

This document provides information on the following technologies: (i) cereal crops, (ii) grain legumes, oilseeds and fibre crops, (iii) horticultural crops, (iv) crop and livestock production technologies, and (v) agricultural processing and utilization technologies.

Fanners in Malawi are kindly requested to use these agricultural technologies so as to increase and improve agricultural productivity. Increased crop and livestock productivity can only be realized through the use of improved crop varieties, animal breeds, and crop and livestock production technologies.

Besides the use of improved crop cultivars,

A.P. Mtukuso, Ph.D.
Director of Agricultural Research Services
I would like to thank all agricultural Research scientists (plant breeders, agronomists, plant pathologists, entomologists, soil scientists, animal breeders, animal husbandry scientists, biometricians) and agricultural extension field staff in both public and private sector organizations who have worked tirelessly over the last six years (since 2000) to develop the agricultural technologies that are presented in this document. These scientists are drawn from different disciplines and many public and private sector organizations, as follows: (i) plant breeders from DARS, ARET, TRF, Monsanto-Malawi, Bunda College of Agriculture, SeedCo Malawi, Pannar Seed Company, Pioneer Seed Company, MRI of Zambia, (ii) animal breeders and husbandry Research officers from DARS, Department of Animal Health and Livestock Development (DAHLD) and Bunda College of Agriculture, (iii) agronomists, entomologists, soil scientists, pathologists, nematologists and plant protection scientists from DARS, Lilongwe Agricultural Development Division (LADD), Farmers' Organization, and Chemicals and Marketing Company Limited., and (iv) agricultural engineering experts from DARS.

In particular, I would like to commend the following: Dr. G.W. Nhlane, Dr. R. Ganunga, Mr. E. Kapcwa, Dr. M.H.P. Banda, Dr. R.M. Chirwa, Dr. V. Aggrawal, Mr. C.L. Kapapa, Mr. L. Nsapato, Mr. Kachigamba, Dr. J.M. Bokosi, Dr. H.N. Soko, Dr. H.E. Nyirenda, Mr. E. Chilhu, Kumwenda, Mr. T. Mzengeza, Mr. W.A. Kanyika, Mr. E. Chilhu, Dr. H.E. Nyirenda, Mr. I. Mphangwc, Mr. P.T. Klionje, Dr. P. Ngwira (Lite), Ms. C.C. Mtambo, Mr. Singano, Mrs. Mkandawirce, Mr. E.L.D. Mazuma, Mr. A.D.C. Chirimba, Mrs. J.Jere, Ms. M.S. Phiri, Mrs. J.C. Clukuse, Dr. W. D. Sakala, Dr. V. H. Kabambe, Mr. H. Kazembe, Dr. Wessell, Dr. Mucliena, Dr. Lupende, Dr. J.D.T. Kumwenda, Mr. P. Khambo, Mr. W.B.C. Chipeta, Mr. Phiri, Mr. Chimimba and Mr. Nkhoma.

Special thanks are due to Mr. C.A. Makato, former Principal Agricultural Liason Officer, for earlier efforts in effectively communicating information on crop varieties to all stakeholders as reported in the 1997 edition of "Crop Varieties Grown in Malawi".

The Officers-in-Charge of the sixteen DARS agricultural experimental sites and the heads of other public and private sector organizations are thanked for providing various resources (physical, human and financial) used in the generation of new agricultural technologies presented in this document. Further, I am highly indebted to all (he farmers on whose fields on-farm trials and demonstrations were conducted.

Financial support for the Agricultural Technology Clearing Committee (ATCC) is provided to the Department of Agricultural Research Services (DARS) by the Malawi Government through the Ministry of Agriculture and Food Security.

A.R. Saka, Ph.D.
Assistant Director of Agricultural Research Services
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<thead>
<tr>
<th>ACRONYMS AND ABBREVIATIONS</th>
<th>DESCRIPTION</th>
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<tr>
<td>ADD</td>
<td>Agricultural Development Division</td>
</tr>
<tr>
<td>ALS</td>
<td>Angular Leaf Spot</td>
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<tr>
<td>ARET</td>
<td>Agricultural Research and Extension Trust</td>
</tr>
<tr>
<td>ATCC</td>
<td>Agricultural Technology Clearing Committee</td>
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<tr>
<td>BCMV</td>
<td>Bean Common Mosaic Virus</td>
</tr>
<tr>
<td>BMC</td>
<td>Bean Mosaic Virus</td>
</tr>
<tr>
<td>BNF</td>
<td>Biological Nitrogen Fixation</td>
</tr>
<tr>
<td>CAETS</td>
<td>Controller of Agricultural Extension and Technical Services</td>
</tr>
<tr>
<td>CD</td>
<td>Clubroot Disease</td>
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<tr>
<td>CIMMYT</td>
<td>International Maize and Wheat Improvement Research Centre</td>
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<tr>
<td>CM</td>
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<td>CMVD</td>
<td>Cassava Mosaic Virus Disease</td>
</tr>
<tr>
<td>CR</td>
<td>Common Rust</td>
</tr>
<tr>
<td>CRSP</td>
<td>Collaborative Research Support Program</td>
</tr>
<tr>
<td>CSB</td>
<td>Cassava Stem Borer</td>
</tr>
<tr>
<td>DARS</td>
<td>Department of Agricultural Research Services</td>
</tr>
<tr>
<td></td>
<td>Director of Agricultural Research Services</td>
</tr>
<tr>
<td>EC</td>
<td>Emulsifiable Concentrate</td>
</tr>
<tr>
<td>ER</td>
<td>Ear Rots</td>
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<tr>
<td>FAO</td>
<td>Food and Agriculture Organization of the United Nations</td>
</tr>
<tr>
<td>FBD</td>
<td>Fusarium Bark Disease</td>
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<tr>
<td>FWD</td>
<td>Fusarium Wilt Disease</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
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<tr>
<td>GLS</td>
<td>Gray Leaf Spot</td>
</tr>
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<td>ICRISAT</td>
<td>International Crops Research Institute for the semi-Arid Tropics</td>
</tr>
<tr>
<td>IITA</td>
<td>International Institute for Tropical Agriculture</td>
</tr>
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<td>LADD</td>
<td>Lilongwe Agricultural Development Division</td>
</tr>
<tr>
<td>LB</td>
<td>Leaf Blight</td>
</tr>
<tr>
<td>LC</td>
<td>Local Chicken</td>
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<tr>
<td>LGB</td>
<td>Larger Grain Borer</td>
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<td>LR</td>
<td>Leaf Rust</td>
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<td>MCMV</td>
<td>Maize Chloride Mottle Virus</td>
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<tr>
<td>MoAFS</td>
<td>Ministry of Agriculture and Food Security</td>
</tr>
<tr>
<td>MoAIFS</td>
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<td>MRI</td>
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<td>NGO</td>
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<tr>
<td>NSCM</td>
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<td>OPV</td>
<td>Open Pollinated Variety</td>
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<td>QPM</td>
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<tr>
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<td>Sweet potato Vims Disease</td>
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<td>SPW</td>
<td>Sweet potato Weevil</td>
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<tr>
<td>TLB</td>
<td>Turcicum Leaf Blight</td>
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<tr>
<td>TRF</td>
<td>Tea Research Foundation of Central Africa</td>
</tr>
<tr>
<td>USA</td>
<td>United States of America</td>
</tr>
<tr>
<td>VRC</td>
<td>Variety Release Committee</td>
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<tr>
<td>WG</td>
<td>Wettatable Dispersible Granule</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
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<tr>
<td>WSB</td>
<td>White Stem Borer</td>
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Chapter 1: Introduction

1.1 Background
Malawi's economy is heavily dependent on agriculture. Agriculture contributes 35-40% of the gross domestic product (GDP), 85-90% of the foreign exchange earnings, employs more than 85% of the work force, provides 60-70% of the inputs into the manufacturing sector, and dominates the commercial and distribution industry (World Bank, 1992; 1995; FAD, 1998, Saka et al., 2002). The main food crops include: maize, groundnuts, cassava, sweet potatoes, beans, soybeans, pigeon peas, rice, sorghum, millets, vegetables and fruits. The main cash crops are: tobacco, tea, sugar, coffee, cashew nuts and macadamia nuts, livestock, mainly consisting of cattle, goats, sheep, pigs and poultry, are also kept by many farmers, especially chicken, and are mainly consumed locally with a tiny proportion destined for the export market.

However, the productivity of these crops, and livestock, especially under smallholder farm conditions, is low. This low productivity can be attributed to many factors including: (i) use of unimproved crop varieties and animal breeds, (ii) use of poor agronomic and crop/livestock husbandly practices, (iv) poor soil and water management practices, (v) inadequate livestock feeds, (vi) frequent recurrent droughts and Hoods, (vii) land degradation due to poor agricultural practices, deforestation, overgrazing, declining fallow periods and the unsustainable use of the common pool assets, and (viii) uncontrolled insect pests, diseases and parasites.

Thus, the challenge lacing Malawi today is to develop production-increasing agricultural technologies (that address the above problems, which constrain agricultural productivity, and boost productivity, while at the same time, conserving Malawi's natural resources.

1.2 Developers of Agricultural Technologies
There are many public and private sector organizations that are currently involved in the development of agricultural technologies aimed at addressing the various biotic and abiotic constraints that limit crop and livestock productivity. These include: (i) Department of Agricultural Research Services (DARS), (ii) Agricultural Research and Extension Trust (ARET), (iii) lea Research Foundation of Central Africa (TRF), (iv) (vii) Seed Suppliers (SeedCo Malawi, Monsanto-Malawi, Pannar Seed Company, Pioneer Seed Company, and Maize Research Institute of Zambia), (viii) Chemical Input Suppliers (Chemicals and Marketing Company limited and Farmers' Organization), and (viii) Bunda College of Agriculture, a constituent College of the University of Malawi. One agricultural technology has been developed by an agricultural extension delivery service organization, Lobi Horticultural Project under Dedza Rural Development Project in Lilongwe Agricultural Development Division (LADD).

1.3 Agricultural Technologies Released From 2000-2005
Starting from 2000, a total of 143 agricultural technologies (crop varieties, crop and livestock production technologies, and agricultural processing and utilization technologies) have been developed by various agricultural experts and approved for farmer use by the
Agricultural Technology Clearing Committee (ATCC) of the Ministry of Agriculture and Food Security (MoAFS). The breakdown of the various technologies is as follows:

(a) One hundred (100) crop varieties;
   • Cereal Crops: (i) Maize (34), (ii) Rice (6), and (iii) Sorghum (5),
   • Legume and Fibre Crops: (i) Groundnut (4), (ii) Bambara nut (3), (iii) Bean (5), (iv) Soybean (3), (v) Pigeon pea (4), (vi) Cowpea (2), and (vii) Sunflower (1),
   • Horticultural Crops: (i) Cotton (5), (ii) Tomato (4), (iii) Macadamia (1), (iv) Cassava (4), (v) Sweet potato (4), (vi) Yam (4), and (vii) Paprika (1),
   • Tobacco (2), and
   • Tea (8).

(b) Forty (40) crop and livestock production technologies:
   • Cereal Crops: (i) Maize (13), and Rice (4)
   • Fibre crops: (i) cotton (11),
   • Horticultural Crops: (i) Tomato (3), (ii) Cabbage (3), (iii) Paprika (1), (iv) Banana (1), and (v) Coffee (1).

(c) Two (2) agricultural processing and utilization technologies:
   • Fruit juice extracting machine (1), and
   • Procedures and/or recipes for making ready-to-drink juices and jams (1).

1.4 The Ultimate Challenge
The ultimate challenge in the technology development and dissemination process is adoption and utilization by farming communities, with the aim of increasing crop and livestock productivity, hence ensuring food security, poverty reduction, and the sustainable management and utilization of Malawi's natural resources. Thus, through the publication of this document, stakeholders in the agriculture sector will be aware of the availability of the so many new agricultural technologies that they can use to significantly increase agricultural productivity.
Chapter 2: Crop Varieties

2.1 Cereal Crops

Sonic 43 cereal crop varieties have been developed and released over the last six years (2000-2005) for the following crops: (i) maize, (ii) rice, and (iii) sorghum.

2.1.1 Maize "Chimanga"

Maize (*Zea mays* L..) is the main staple food crop in Malawi that is grown in all the twenty seven districts. Two main types of maize are grown: (i) hybrid maize, and (ii) open pollinated maize varieties (OPVs). OPVs comprise composite and synthetic varieties.

2.1.1.1 Maize hybrids

There are twenty-eight maize hybrids that have been developed by various organizations including: (i) Department of Agricultural Research Services (DARS), (ii) Monsanto Malawi limited, (iii) Pannar Seed Company limited, (iv) SeedCo Malawi Limited, (vi) Pioneer Seed Company limited, and (vii) Maize Research Institute of Zambia (MRI). The different crop varieties are briefly described below.

1. Thanzi {CML144xCML176xCML158] Partially released in 2002 by the National Maize Breeding Programme in collaboration with CIIMMYT in Harare, Zimbabwe. This is a three-way cross semi-dent high quality protein maize (QPM) hybrid that is white in colour and of medium maturity. It is tolerant to gray leaf spot (GLS), common rust and cob rots. It has an average yield potential of more than 5,000 kg/ha. This high quality protein maize hybrid is aimed at improving the nutritional status of highly vulnerable groups, such as children and the elderly. This is the first QPM variety to be officially released in Malawi.

2. CZR 3 Released in November 2002 by the National Maize Breeding Programme. CZR 3 is a double-cross flint-grained maize hybrid that is white in colour, and suited to a wide range of environments. It is a medium maturing hybrid (130-133 days) with high mphale extraction. It has good husk cover and is resistant to lodging, with a yield potential of 7,000 kg/ha. This hybrid is poundable and tolerant to GLS, *Turcicum leaf* blight (TLB) and maize streak virus (MSV).

3. CZR 4 Released in November 2002 by the National Maize Breeding Programme. CZR 4 is double-cross, flint-grained maize hybrid that is white in colour and suited to a wide range of environments. It is a medium maturing maize hybrid (130-133 days) with a yield potential of 9,000 kg/ha. It has good husk cover, and is medium in height with good resistance to lodging. CZR 4 is tolerant to most common maize diseases, including GLS, TLB and MSV. Because of its flintiness, it is poundable and has high mphale extraction.
4. CZR 8
Released in November 2002 by the National Maize Breeding Programme. This is a three-way cross maize hybrid that is flint-grained with a white colour and adapted to a wide range of environments. It is medium maturing (130-133 days) with a yield potential of 10,000 kg/ha. It has good husk cover, medium in height, and has good resistance to lodging. CZR 8 is tolerant to most common maize diseases, including GLS, TLB and MSV. This maize hybrid is poundable and has high mphetamine extraction.

5. DK 8031
Released in August 2001 by Monsanto-South Africa through the National Seed Company of Malawi (NSCM) in collaboration with the National Maize Breeding Programme. This is a three-way cross dent-grained maize hybrid that is widely adapted in Malawi, although it is better suited to low altitude areas (<500 m days), such as the Shire valley and the Lakeshore plain. It is a short duration maturing maize hybrid (115-120 days) with good tolerance to drought stress, GLS, ear rots (ER), common rust, but has moderate tolerance to MSV. It has a yield potential of between 6,000 and 8,000 kg/ha.

6. DK 8041
Released in September 2000 by Monsanto-South Africa through NSCM in collaboration with the National Maize Breeding Programme. This is a medium duration maturity maize hybrid (130-135 days) that is a modified single cross hard-dent hybrid that is tolerant to GLS, ER and cob rots, but has moderate tolerance to MSV. It is widely adapted in Malawi, but more especially suited to the medium altitude plateau (500-1,500 m asl). It has a yield potential of between 7,000 and 9,000 kg/ha.

7. DK 8051
Released in August 2001 by Monsanto-South Africa through NSCM in collaboration with the National Maize Breeding Programme. This is a medium to late maturing (145-150 days) three-way cross semi-dent maize hybrid that is tolerant to GLS, ER and cob rots, but has moderate tolerance to MSV. It is a short stature variety with semi-erect leaves. It is widely adapted in Malawi, although it is better adapted to the medium altitude plateau areas characterized by sufficient rainfall that is evenly distributed during the effective crop growing season. It has a yield potential of between 7,000 and 10,000 kg/ha.

8. DK 8071
Released in September 2000 by Monsanto-South Africa through NSCM in collaboration with the National Maize Breeding Programme. This is a medium to late maturing (140-145 days) semi-flint grained maize hybrid that is tolerant to GLS, ER and cob rots, but moderate tolerance to MSV. It produces two cobs per plant and is better adapted to medium altitude areas (500-1,500 m asl) with good rainfall distribution. It has a yield potential of between 7,000 and 10,000 kg/ha.

9. DKC 8033 (Mtetezi)
Released in August 2003 by Monsanto (Malawi) Limited in collaboration with the National Maize Breeding Programme. This is a prolific white hard dent-grained early to medium maturing hybrid maize that is recommended for medium altitude areas of Malawi. It has outstanding standability and is stable across all medium altitude environments. It has high tolerance to MSV, GLS, TLB and CR, with a yield potential of 6,000-12,000 kg/ha. Because of its high tolerance to MSV, it is highly suitable for dimba cultivation during the dry winter months. This variety is a good alternative to NSCM 31, 51 and 91.

10. DKC 80-73
Released in August 2005 by Monsanto (Malawi) Limited in collaboration with the National Maize Breeding Programme. DKC 80-73 is a three-way cross maize hybrid that is white in colour and matures in 120-140 days. It is a highly prolific, Hint-grained maize hybrid that is high yielding (7,000-10,000 kg/ha), mid adapted to a wide range of environments (700-1,550 m asl) that receive between 550 and 950 mm of rain per year. It has large grains, good
husk cover and excellent standability. It has good tolerance to the most common leaf diseases, such as GLS, MSV, cob rot and TLB. DKC 80-73 is liked by both producers and consumers because of its flintiness, and good profitably because it can be grown under both rain-fed and irrigated conditions.

11. PAN 33
Released in 2003 by Pannar (Pvt.) limited of Soudi Africa in collaboration with the National Maize Breeding Programme. PAN 33 is a white, flint-grained, medium season (138-146 days to maturity); double-cross maize hybrid that is very prolific (2 cobs under low plant populations). It is high yielding (up to 7,000 kg/ha), tolerant to MSV, good resistance to cob rots, good resistance to common rust, GLS and Northern Leaf Blight (NLB). It has good husk cover, mid is adapted to a wide range of environments. The main attributes are its flintiness and resistance to MSV. As such, PAN 33 is highly liked by consumers because of its poundability and suitability for dimba cultivation during the dry season under both irrigated and residual soil moisture conditions.

12. PAN 77
Released in 2003 by Pannar (Pvt.) limited of South Africa in collaboration with the National Maize Breeding Programme. PAN 77 is a white, Hint-grained, medium season maturity (136-144 days), double-cross maize hybrid that is very prolific (2 cobs under low plant populations) and yield potential of up to 6,500 kg/ha. It has excellent resistance to MSV, good resistance to cob rot, good resistance to common rust, very good resistance GLS and good resistance to NLB. It is adapted to a wide range of environments. The main attributes of this hybrid are its resistance to MSV and GLS, and its flintiness, making highly suitable for local processing and cultivation in dimbas along river valleys and dambos.

13. PAN 57
Partially released in November 2005 by Pannar (Pvt) Limited of South Africa in collaboration with the National Maize Breeding Programme. PAN 57 is a high yielding (>6,000 kg/ha), medium season (135 and 144 days for warm and cool areas, respectively) maturity double cross maize hybrid that is widely adapted to many environments, especially in areas where MSV and other leaf diseases are prevalent. This hybrid has good quality Hint grain, good husk cover and strong stalks of short to medium height, as well as showing excellent resistance to GLS, NLB, cob rot and MSV; and good resistance to common rust. The main attributes of this variety are its resistance to leaf diseases and flintiness, and therefore, highly suitable for local processing and cultivation in dimbas along river valleys and dambos.

14. PAN 63
Partially released in November 2005 by Pannar (Pvt) Limited of South Africa in collaboration with the National Maize Breeding Programme. PAN 63 is a double cross maize hybrid that is high yielding (>6,000 kg/ha), medium maturing (139 and 148 days for warm and cool areas, respectively), and adapted to a wide range of environments. It has good quality flint grain, good husk cover and strong stalks of medium height, as well as good resistance to GLS, NLB, cob rot and MSV, and good resistance to common rust. The main attributes of this variety include resistance to leaf diseases, flintiness and its suitability for dambo and upland cultivation.

15. SC 407
Released in September 2000 by SeedCo limited of Zimbabwe in collaboration with the National Maize Breeding Programme. This is a very early maturing (132 days), semi-dent white-grained maize hybrid with a yield range of between 1,000 and 5,000 kg/ha. It combines the good levels of tolerance to MSV, maize chlorotic mottle virus (MCBV) and GLS. It has good pollen to silk synchronization that makes it suitable for marginal rainfall areas, such as the lakeshore plain and the Shire valley. It is also suitable for dimba cultivation.

16. SC 501

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Released in September 2000 by SeedCo Limited of Zimbabwe in collaboration with the National Maize Breeding Programme. This is a very early maturing (134 days), semi-dent white-grained maize hybrid with a yield range of between 3,000 and 6,000 kg/ha that is adapted to all maize growing environments. It is susceptible to MSV, has very low levels of tolerance to TLB and GLS, but it is tolerant to drought. Thus, it is not suitable for dimba cultivation because of its susceptibility to MSV.

17. SC 513

Released in August 2002 by SeedCo Limited of Zimbabwe in collaboration with the National Maize Breeding Programme. This is a high yielding (4,000-9,000 kg/ha), early maturing maize hybrid (137 days) that is white and dent-grained. It has very good tolerance to GLS, moderately resistant to cob rots, but good tolerance to drought. It has high ear placement but slightly susceptible to root lodging.

18. SC 515

Released in September 2000 by SeedCo Limited of Zimbabwe in collaboration with the National Maize Breeding Programme. This is an early maturing (134 days), white dent maize hybrid with a yield range of between 3,000 and 6,000 kg/ha. It is adapted to a wide range of maize growing environments. It has good tolerance to GLS, relatively good tolerance to MSV and TLB.
19. SC 633
Released in August 2003 by Seed Co of Zimbabwe through the National Maize Breeding Research Programme. This is a white-dent medium maturing (139 days) single cross maize hybrid with good tolerance to MSV, but moderate resistance to GLS. It has a high yield potential (5,000-12,000 kg/ha), and is higher yielding than the recommended MH 18, SC 627, NSCM 31 and PAN 67. It is adapted to a wide range of agro-ecologies, but where GLS is not a major threat, such as low altitude areas. Because of its high tolerance to MSV, it is very suitable for *dimba* cultivation. This hybrid is higher yielding than SC 627, and is an important addition to the medium maturing range of hybrids from Seed Co.

20. SC 627
Released in September 2000 by SeedCo Limited of Zimbabwe in collaboration with the National Maize Breeding Programme. This is a medium maturing maize hybrid (144 days) that is while, semi dent-grained hybrid with a yield range of between 5,000 and 10,000 kg/ha. It has good levels of tolerance to MSV and GLS. SC 627 is suitable for production in a wide range of environments characterized by good rainfall distribution during the growing season. SC 627 is highly suitable for *dimba* cultivation under both irrigated and residual soil moisture because of its good tolerance to MSV.

21. SC 709
Released in September 2000 by SeedCo Limited of Zimbabwe in collaboration with the National Maize Breeding Programme. This is a high yielding (6,000-13,000 kg/ha), late maturing (151 days) while dent-grained maize hybrid. It has good tolerance to GLS and MSV, and adapted to all high potential maize growing areas on the medium altitude plateau (500-1,350 m asl) with good rainfall distribution throughout the growing season. It is also tolerant to heat and drought stresses.

22. SC 713
Released in August 2002 by SeedCo Limited of Zimbabwe in collaboration with the National Maize Breeding Programme. This is a high yielding (6,000-13,000 kg/ha), late maturing (151 days) white dent-grained maize hybrid with good tolerance to GLS and MSV. It is adapted to all medium altitude plateau areas (500-1,300 m asl) characterized by good rainfall distribution throughout the growing season. SC 713 has a slightly longer car than SC 709.
23. SC 715
Released in August 2002 by SeedCo Limited of Zimbabwe in collaboration with the National Maize Breeding Programme. This is a high yielding (5,000-11,000 kg/ha), late maturing (152 days) white dent-grained maize hybrid with good standability and stability. It has excellent tolerance to GLS, good tolerance to cob rots and MSV, but very good tolerance to ER. However, it is marginally worse in lodging compared with SC 709, so that it should not be planted at more than 50,000 plants/ha.

24. SC 717
Released in August 2002 by SeedCo Limited of Zimbabwe in collaboration with the National Maize Breeding Programme. This is a high yielding (6,000-13,000 kg/ha) white semi dent-grained maize hybrid that is late maturing (152 days), moderately tolerant to MSV, and good tolerance to cob rots. However, it has a higher GLS scores when compared with SC 709. It has a good tip cover, long cobs, and is highly liked by producers and consumers because of its semi-flint grain texture. This hybrid is adapted to all high rainfall areas on the medium to high altitude plateau areas, provided there is good rainfall distribution throughout the growing season.

25. PHB30G97
Released in 2001 by Pioneer Overseas Corporation of Zimbabwe in collaboration with the National Maize Breeding Programme. This is an early to medium maturity (110-120 days) white, flint-grained maize hybrid dial is adapted to medium altitude plateau areas (500-1,300 m asl). It has a high yield potential (7,000-10,000 kg/ha) with good resistance to GLS, TLB, LR and cob rot; but with medium resistance to MSV.

26. PHB30H83
Released in 2001 by Pioneer Overseas Corporation of Zimbabwe through the National Maize Breeding Research Programme. This is a white flint-grained maize hybrid of medium maturity (120 days) adapted to the medium altitude areas (500-1,300 m asl). It has a high yield potential (7,000-10,000 kg/ha) with good resistance to GLS, TLB, leaf rust and cob rot; but with medium resistance to MSV.

27. MRI724
Released in November 2001 by the Maize Research Institute (MRI) of Zambia in collaboration with the National Maize Breeding Programme. This is a medium maturity white, semi-dent three-way cross maize hybrid that has good resistance to GLS (Cereospora zca-maydis), TLB, MSV, and cob rots, but has medium resistance to common rust (Puccinia sorgi) and Turcicum. It has a high yield potential (8,000-13,000 kg/ha) and is adapted to all suitable maize growing environments in Malawi, particularly medium and high altitude plateau areas (500-1,1,300 m asl).

28. MRI 734
Released in November 2001 by the Maize Research Institute (MRI) of Zambia in collaboration with the National Maize Breeding Programme. This is a medium maturity, white, semi-dent three-way cross maize hybrid that has good resistance to GLS, TLB, MSV, cob rot and common rust. It has a high yield potential (7,000-10,000 kg/ha) and is best adapted to medium altitude plateau areas (500-1,500 m asl), although it does better in a wide range of environments.

2.1.1.2 Open pollinated maize varieties
There are six open pollinated maize varieties comprising live composites and one synthetic variety. These have been developed by DARS and Afgri Seed Company of South Africa.

29. ZM 421
Released in 2001 by the National Maize Breeding Programme. This is an early maturing (110-120 days) white, semi-flint grained OPV with a yield potential of 4,000-5,000 kg/ha. It has tolerant to GLS, TLB, common rust, and MSV. It is also tolerant to drought and low soil nitrogen conditions, and is mainly suited to low altitude areas below 500 m asl.

30. ZM 521
Released in August 2001 by the National Maize Breeding Programme. This is a medium maturity (130 days) semi-Hint grained OPV with a yield potential of 6,000-7,000 kg/ha. It is tolerant to GLS, TLB, common rust and MSV. It is also tolerant to low soil-water and nitrogen stressing conditions. It is suited to both low and medium altitude maize growing areas (< 1,300 m asl) throughout the country.

31. ZM 611
Released in August 2003 by the National Maize Breeding Research Programme. This is a high yielding OPV that is tolerant to drought and low nitrogen, is resistant to GLS, and MSV diseases. It has a high yield potential (6,000-8,000 kg/ha). It yields 14-20% more than Masika. It is adapted to a wide range of agro-ecologies. ZM 611 is white and has a good husk cover, is medium in height and has good resistance to lodging.

32. ZM 623
Released in August 2003 by the National Maize Breeding Research Programme. This is a high yielding OPV that is tolerant to low pH (aluminium toxicity), low nitrogen, GLS, TLB and MSV diseases. It has a high yield potential (7,000-9,000 kg/ha), and yields 19% more than the recommended Masika maize variety. It is adapted to a wide range of agro-ecologies in Malawi and is characterized by good husk cover, is medium in height, and has good lodging resistance.

33. ZM 621 (Masuku)
Released in 2000 by the National Maize Breeding Programme. This is a medium to late maturity OPV with white and semi-flint grain texture. It has a yield potential of between 5,000-6,000 kg/ha and is suitable for both low and medium altitude plateau areas (< 500 m asl). ZM 621 has mild tolerance to drought, low nitrogen levels, and foliar diseases.

34. AFRIC 1
Released in August 2004 by Algri Seed of Soudi Africa in collaboration with the National Maize Breeding Programme. AFRIC 1 is a white, flint-dent, early to medium maturity (120-146 days) OPV that has specifically been developed for use by small-scale farmers. It is a high yielding (8,000 kg/ha) maize variety that is moderately tolerant MSV mid TLB, good tolerances cob rot and leaf rust, excellent tolerance to GLS, good tolerance to drought, and resistant to lodging. It is adapted to all maize growing environments. Its main attributes include high yield potential, flintiness, moderate resistance to MSV and excellent tolerance to GLS.

2.1.2 Rice "Mpunga"
Rice (*Oryza saliva* L.) is the second most important cereal food crop in Malawi. Six new rice varieties have been developed over the last six years.

1) Vyawo
Released in 2000 by the National Rice Breeding Programme. Vyawo, in the Tonga language, translates into 'theirs'. This name refers to the variety's resistance to rice blast and particularly to its adaptability to the Nkhata Bay low altitude areas. This variety is not scented, but its long grain has good flavour. The grain measures 9.1 mm by 2.5 mm, with a 68% milling yield. The variety takes 130 days to mature in the wet season and 150 days in the dry season. It is also suitable for double cropping if sown before 15"June. It is suited for production in all irrigation schemes and has grain yield potential of 6,000 kg/ha in the wet season and 5,500 kg/ha in the dry season.
2) Mtupatupa
Released in 2000 by the National Rice Breeding Programme. The name Mtupatupa means 'expanding' in the ChiChewa language, referring to the variety's grain that expands when cooked. The variety is intermediate in height (110-120 cm) with medium-shaped grains that are moderately scented. The grains average 9.2 mm in length and 2.7 mm in width, with a milling percentage of 66%. It matures in 130 days in the wet season and 155 days in the dry season. It is also recommended for double cropping if sown before 15" June. It is suited for production in all irrigation schemes, mainly because of its tolerance to rice diseases. It has a yield potential of 6,300 kg/ha and 6,000 kg/ha in the wet and dry seasons, respectively.

3) Nunkile
Released in 2000 by the National Rice Breeding Programme. Nunkile means "smells good" in the ChiNkhonde language, which accurately describes this strongly scented rice variety. It is semi-dwarf (<100 cm) with grains measuring 9.8 mm and 2.3 mm in length and width, respectively; and has a milling yield of 68%. This is a short maturing variety: 112 days in the wet season and 140 days in the dry season. It has potential yields of 6,000 kg/ha and 5,500 kg/ha in the wet and the dry seasons, respectively. It is moderately susceptible to the common rice blast disease (Pyricularia oryzae), hence it is not suited to blast prone areas, such as Limphasa Irrigation Scheme, and most of the medium altitude areas (<500 m asl) throughout the country. Nunkile matures two weeks earlier than Senga or Changu. Such being the case, yield losses due to birds is particularly high. Hence bird scaring should always start early. Because of its strong scent, Nunkile is also very attractive to field mice.

4) Lifuwu (FRX 78-12)
Released in August 2003 by the National Rice Breeding Programme. This is an early maturing (90-120 days) high quality (good milling, cooking and taste qualities) rice variety with high levels of adaptability. It yields between 4,500-5,500 kg/ha, which is higher than the average yield of the two recommended local varieties: Faya and Kilombero, which average 2,900 kg/ha. It is less susceptible to the devastating rice blast disease (RBD). This variety is highly preferred by consumers because of its good aroma and long grains.

5) Wambone (FRX 92-14)
Released in August 2003 by the National Rice Breeding Programme. This is a medium maturing (more than 120 days), high quality (good milling, cooking and taste qualities) rice variety with a high level of adaptability. It is higher yielding (4,500-5,700 kg/ha) when compared with the two local varieties Faya and Kilombero that average 2,900 kg/ha. It is stable and less susceptible to the devastating RBD. It is a semi-dwarf variety that responds to high levels of fertilization without lodging. This variety is also highly liked by consumers in Malawi because it is scented and has long grains.

6) Kameme (IRAT 170)
Released in August 2003 by the National Rice Breeding Programme. IRAT 170 is an early maturing (90-120 days), stable rice variety that is highly resistant to RBD. It is adapted to high altitude areas, such as Chitipa, which are prone to rice blast. It is slightly lower yielding than the recommended local varieties Faya and Kilombero, which average 2,900 kg/ha, although relatively high yields (of up to 3,700 kg/ha) have been obtained at Meru in Chitipa. This is a semi-dwarf variety that responds well to high levels of fertilization without lodging. Although this variety is not scented, it is preferred by farmers because of its tolerance to rice blast, especially in upland areas.

2.1.3 Sorghum "Mapira"
Sorghum (Sorghum bicolor) is extensively grown in the Shire valley and some areas along the lake shore and the Phalombe plains. Eight sorghum varieties have so far been released for growing under smallholder farm conditions.

1. Gwiramtima (Acc 1052)
Released in 2003 by the National Sorghum and Pearl Millet Breeding Programme. This is a high yielding (2,400-3,500 kg/ha), very tall (331-400 cm) and very early maturing (100-105 days) sorghum variety that is disease, insect pest and drought tolerant. It is photoperiod insensitive, and has an intermediate, hard creamy white medium-sized grain type that is highly nutritious and greatly favoured by consumers because of its excellent food quality and palatable taste. Gwiramtima (meaning eating with satisfaction in the chiSena language) is especially recommended for the Shire valley.

2. Makolokoto (Acc 1002)
Released in August 2003 by the National Sorghum and Pearl Millet Breeding Programme. This is a high yielding (2,100-3,700 kg/ha), tall (338-360 cm), late maturing (130-140 days) sorghum variety that is disease and insect pest tolerant, drought tolerant and photoperiod insensitive. It has an intermediate, hard creamy white medium-sized grain that is highly nutritious and favoured by consumers. It has an excellent polished grain quality that has excellent food qualities with a palatable taste. Makolokoto (meaning completely satisfied in the chiSena language) is recommended for the Shire valley.

3. Sinakhomo (Acc 952)
Released in 2003 by the National Sorghum and Pearl Millet Breeding Programme. This sorghum variety has a yield potential of up to 3,000 kg/ha, is tall (338-360 cm) and is a very early maturing (100-112 days) sorghum variety that is disease and insect pest tolerant, drought tolerant and photoperiod insensitive. It has an intermediate, hard creamy white medium-sized grain that is highly nutritious and favoured by farmers and consumers. It has an excellent polished grain quality with good food quality and taste. Sinankhomo (meaning eating without end in chiSena) is recommended for the Shire valley as well.

4. Kayera (Acc 953)
Released in August 2003 by the National Sorghum and Pearl Millet Breeding Programme. This is a high yielding (2,100-3,000 kg/ha), very tall (342-355 cm), early maturing (115-121 days) sorghum variety that is disease and insect pest tolerant, drought tolerant and photoperiod insensitive. It has an intermediate, hard creamy white medium-sized grain that is highly nutritious and preferred by farmers and consumers. It has an excellent polished grain quality, good Hour and palatability. Kayera (meaning white-grained in the chiSena) is recommended for sorghum growing areas in Machinga, Salima and Karonga districts.

5. Acc 967
Released in August 2003 by the National Sorghum and Pearl Millet Breeding Programme. This is a high yielding (2,000-3,500 kg/ha), tall (290-314 cm), early maturing (115-121 days) sorghum variety that is disease and insect pest tolerant, drought tolerant and photoperiod insensitive. It has an intermediate, hard creamy white medium-sized grain that is highly nutritious and favoured by farmers and consumers. It has an excellent polished grain quality, good Hour quality and good food palatability taste. Acc 967 is recommended for sorghum growing areas in Machinga, Salima and Karonga districts.

2.2 Grain Legumes, Oilseeds and Fibre Crops
Crop varieties have been developed for the following crops: (i) groundnuts, (ii) bambara nut, (iii) beans, (iv) soyabean, (v) pigeonpea, (vi) cowpea, (vii) sunflower, and (viii) cotton.

2.2.1 Groundnut "Mtedza"
Groundnut (*Arachis hypogaea*) is a very important crop for food and market sale. It is also an important commodity in the confectionery trade, and when grown in rotation with cereals, such as maize, groundnut improves soil fertility through the process of Biological Nitrogen Fixation (BNF). Because of this, several varieties have been developed and released for commercial production. A brief description of the officially released varieties is given below.
1. Kakoma QL 24

Released in 2000 by the National Groundnut Breeding Programme. Kakoma, originally known as JL24, is an erect bunch type that is recommended for rain-fed production in all low lying areas (<500 m asl), such as the Shire valley and the lakeshore plain, and also for dimba cultivation under residual soil moisture in dimbas. It is drought tolerant and matures in 90-120 days after planting. Kakoma has no fresh seed dormancy, so that it should be harvested as soon as it matures. The seeds are medium (38 g/100 seed) in size, sweet, pale tan in colour with 48% oil content, making them suitable for the confectionery trade.

2. Baka (ICG 12991)

Released in 2001 by the National Groundnut Breeding Programme. Baka was originally known as ICG 12991, and like Kakoma, it is another erect bunch type dial is recommended for production in all low lying areas (<500 m asl), such as the Shire valley, and along the Lakeshore plain in Karonga and Salima districts. It is also suitable for dimba cultivation during the dry season (winter months). Baka has the added advantage in that it is rosette resistant and is relatively early maturing (90-100 days) when compared with other groundnut varieties, including Kakoma. It is also drought tolerant, and like Kakoma, has no fresh seed dormancy and should, therefore, be harvested as soon as it matures. Baka has small seeds (31g/100 seed) that are sweet and roundish in shape. The colour of the testa is pale tan, and has 43% oil content and 27% protein. This makes Baka suitable for the confectionery trade, particularly for the manufacturing of canthes, biscuits, and yogurt; among many other items.

3. Chitala (ICGV-SM 99568)

Released in 2005 by the National Groundnut Breeding Programme. Chitala (ICGV-SM 99568), which is a cross between ICGV 93437 and ICGV-SM 93561, is a high yielding (>2000 kg/ha) confectionary groundnut variety that belongs to the Spanish botanical group with an erect growth habit. It has sequentially branching and medium-sized light green leaves. The pods have a medium reticulation, a slight to medium constriction and a small beak. It matures in 90-105 days on the medium altitude plateau, such as Lilongwe plain, and in 90-100 days on low-altitude marginal rainfall areas, such as the Lakeshore plain, and is fairly resistant to rosette. The seeds are large, uniform in size and tan-coloured, with a 100 seed weight of 40 g. The main attributes of Chitala are its large and uniform seed size, tan colour and its resistance to rosette.

4. Chalimbana 2005 (C851/7)

Released in 2005 by the National Groundnut Breeding Programme. Chalimbana 2005 (C851/7), which is a cross between RG1 and Chalimbana is a high yielding (>2,500 kg/ha) confectionary groundnut variety that belongs to the Virginia botanical group. It is moderately resistant to rosette and easier to harvest than Chalimbana. It is an alternately branched and semi-spreading bunch variety that matures in 130-140 days. It is adapted to a wide range of environments in Malawi, especially on the medium altitude plateau. The seeds of Chalimbana 2005 are large and uniform in size, tan-coloured and characterized by a "milky" flavour, like Chalimbana. The pods are large, unconstricted and contain between 1 to 3 large seeds, with 100 seed weight of 65 g. Its main attribute is its distinctive "milky flavour" that made Chalimbana the most popular confectionery nut.

2.2.2 Bambara nut or Ground bean "Zama or Mzama"

Bambara nut (Vigna subterranea (L) Verdic) is an important legume crop that is highly liked by many rural and urban family households as a side relish. Bambara nut is delicious and rich in proteins, carbohydrates and fats. However, no documented evidence exists for the locally grown
cultivars, until recently when three cultivars were characterized by the Malawi National Plant Genetic Resources Centre.

1. Kayera (2768)
Partially released in November 2005 by the Malawi National Plant Genetic Resources Centre. Kayera (Accession 2768) yields an average of about 880 kg/ha, and is adapted to a wide range of environments in Malawi, including marginal rainfall areas, and those with poor soil fertility. Kayera has: (i) 84 g for a 100 seed weight, (ii) 65 pods per plant, (iii) 1 seed per pod, (iv) 60% shelling percentage, (v) 10 stems per plant, (vi) 10 nodes per stem, (vii) 120 cm long inter-nodes, (viii) 32 cm in height, (ix) 169 cm long petioles, (x) 4 cm canopy spread, and (xi) a total of 78 leaves. It takes 53 days to attain 50% flowering and has a banner length of 8 cm, and is susceptible to Antirrhinum and Mosaic diseases.

2. Makata (181Cr)
Partially released in November 2005 by the Malawi National Plant Genetic Resources Centre. Makata (Accession 181Cr) gives a high average yield of 1,160 kg/ha. This variety is adapted to a wide range of environments in Malawi, including marginal rainfall areas characterized by poor soil fertility. It has the following distinguishing characteristics: (i) 92 g for a 100 seed weight, (ii) 38 pods per plant, (iii) 1 seed per pod, (iv) 60% shelling percentage, (v) 7 stems per plant, (vi) 12 nodes per stem, (vii) 37 cm long inter-nodes, (viii) 33 cm high, (ix) 201 cm long petioles, (x) 5 cm canopy spread, and (xi) a total of 55 leaves. It takes 55 days to attain 50% flowering, and has a banner length of 8 cm. This variety is susceptible to Anthracnose and Mosaic diseases.

3. Kadziunde (181 Rd)
Partially released in November 2005 by the Malawi national Plant Genetic Resources Centre. Kadziunde (Accession 181 Rd) gives an average yield of about 900 kg/ha. This variety is also adapted to a wide range of environments in Malawi, including marginal rainfall areas, and those characterized by poor soil fertility. Some of the distinguishing characteristics include: (i) 42 g for a 100 seed weight, (ii) 31 pods per plant, (iii) 1 seed per pod, (iv) 60% shelling percentage, (v) 6 stems per plant, (vi) 8 nodes per stem, (vii) 32 cm long inter-nodes, (viii) a total plant height of 24 cm, (ix) 160 mm long petioles, (x) 5 cm canopy spread, (xi) a total of 55 leaves. It takes 55 days to attain 50% flowering and has a banner length of 8 cm. This variety has the special attribute that its pods bury themselves in the ground so that it does not require any banking at all. This variety is susceptible to Anthracnose and Mosaic diseases.

2.2.3 Bean "Nyemba"
Beans (*Phaseolus vulgaris*) are widely grown in Malawi, being only second to groundnuts on the list of grain legumes. The commonly eaten beans in Malawi include the red, white, speckled or tan types with large seeds (40-50 g/100 seeds) that are kidney shaped. They are mostly used for relish when dry, but the pod leaves are also used frequently by a large number of family households. Two main types of beans can be distinguished: (i) dwarf (bush or determinate) varieties, and (ii) climbing (indeterminate) varieties.

2.2.3.1 Determinate (dwarf) bean varieties
There are three determinate or dwarf bean varieties that have been developed over the last six years. These are the three varieties that have been developed by the CRISP Project at Bunda College of Agriculture.
1. BCMV-B2
Released in March 2005 by the Bean/Cowpea CRSP Project at Bunda College of Agriculture. BCMV-B2 is a brown, small-seeded bean variety with a yield potential of 2,500 kg/ha. It is adapted to a wide range of environments in Malawi, and matures in 80 days under moderate temperatures, and in about 90 days under cool temperatures. This variety has the "protected /gene resistance" giving it excellent resistance against the bean common mosaic virus (CBMV) and the bean common mosaic necrotic virus (BCMNV).

2. BCMV-B4
Released in March 2005 by the Bean/Cowpea CRSP Project at Bunda College of Agriculture. BCMV-B4 is a cranberry, medium-seeded variety with a yield potential of 1,500 kg/ha under maize intercrop, and over 2,000 kg/ha under sole cropping. It is adapted to a wide range of environments in Malawi and matures in 80 days under moderate temperatures, and in about 90 days under cool temperatures. This variety has the "protected /gene resistance", which gives excellent resistance against CBMV and BCMNV.

3. BC-D/O (19)
Released in March 2005 by the Bean/Cowpea CRSP Project at Bunda College of Agriculture. This is another cranberry, medium-seeded variety with a yield potential of 2,000 kg/ha. It is adapted to a wide range of environments in Malawi and matures in 75 and 85 days under moderate and cool temperatures, respectively. This variety also has the "protected /gene resistance" giving it excellent resistance against CBMV and BCMNV.

2.2.3.2 Indeterminate (climbing) bean varieties
Only two indeterminate or climbing beans have been developed so far. These are a product of DARS

4. Sugar 131
Released in 2002 by the National Bean Breeding Programme. This is an Andean medium-seeded cranberry coloured bean variety that is tolerant to most common bean diseases, such as angular leaf spot (ALS) and common bacterial blight (CBB). It is also adapted to low soil fertility conditions. It has a yield potential of more than 1,500 kg/ha in pure stand. It is fast cooking, tastes good, and has a high market potential.

5. UBR (92) 25
Released in 2002 by the National Bean Breeding Programme. This is a Mcso American small-seeded white bean variety that is resistant to black root and BCMV. It is also adapted to low soil fertility conditions, and has a yield potential of more than 1,500 kg/ha in pure stand. It is fast cooking, tastes good, and has a high market potential also.

2.2.4 Soybean "Soya"
Three soybean cultivars have been released and recommended for production over the last six years. These are have all been developed by DARS.

1. Solataire
Fully released in August 2003 by Seed Co-Zimbabwe and Seed Co-Malawi in collaboration with the National Soybean Breeding Programme. This is a determinate soybean variety that originates from Zimbabwe and matures in 86 days. The seed coat is yellow and the helium is gray with a seed size of 20 g/100 seeds. It has a high yield potential of more than 3,500 kg/ha and is widely adapted to most parts of Malawi.
2. **Soprano**

Fully released in August 2003 by Seed Co Zimbabwe and Seed Co Malawi in collaboration with the National Soybean Breeding Programme. This is a determinate soybean variety that originates from Zimbabwe and matures in 89 days. The seed coat is yellow and (the) helium is brown with a seed size of 17 g/100 seeds. It has a high yield potential of more than 3,500 kg/ha and is widely adapted to most parts of Malawi.

3. **747/6/8**

Released in August 2003 by the National Soybean Breeding Research Programme. 747/6/8, which was rejected in 2002, is higher yielding (1958 kg/ha) than the recommended Ocepara-4 (1614 kg/ha). It has a yellow seed coat and a colourless helium, a desirable attribute in the manufacturing of soybean-based products, such as I>ikuni Phala and soymilk. 747/6/8 grows to a height of 75 cm, matures in 123 days, and is adapted to a wide range of environments. It does not lodge as much as Ocepara-4 and takes longer to shatter when compared with Ocepara-4. This variety is recommended based on its yellow colour and its colourless helium.

### 2.2.5 Pigeon pea "Nandolo"

Pigeon pea (*Cajanus cajan*) is mostly grown in southern region of Malawi, although it is now slowly being grown in central and northern regions of the country. The currently recommended varieties, which have mainly been selected for their resistance to *Fusarium* wilt, are described below.

1. **Kachangu (ICEAP 00040)**

   Partially released in 2000 by the National Pigeon pea Breeding Programme in collaboration with the Integrated Pest Management Project. This variety originates from ICRISAT in India. It is resistant to *Fusarium wilt*, a very devastation pigeon pea disease in Malawi. It has a very high potential yield of between 4,000-5,000 kg/ha. It has a seed size of 19 g/100 seeds and grows to a height of 270 cm. It has a creamy white seed colour and is earlier maturing than the local landraces, and is ready for reaping when the local landraces are at the flowering stage. Because of its earliness, farmers have named it "Kachangu".

2. **ICPL 87105**

   Released in August 2003 by the National Pigeon pea Breeding Programme. ICPL 93015 is an early maturing and high yielding (up 2,500 kg/ha) variety that has stable seed and grain yields. It is adapted to a wide range of environments with a high market potential. It grows to a height of 130 cm, matures in 126 days and has large cream seeds with a seed size of 17 g/100 seeds. Because of its earliness in maturity, it tends to escape the *Fusarium wilt* disease. However, for high yields, there is need to spray at flowering and pod filling.

3. **ICPL 87015**

   Released in August 2003 by the National Pigeon pea Breeding Programme. ICPL 93015 is an early maturing and high yielding (up 2,500 kg/ha) variety that has stable seed and grain yields. It is adapted to a wide range of environments with a high market potential. It grows to a height of 130 cm, matures in 126 days and has large cream seeds with a seed size of 17 g/100 seeds. Because of its earliness in maturity, it tends to escape the *Fusarium wilt* disease. However, to attain high yields, three sprays of pesticides are required during the flowering and pod filling stages.

4. **ICPL 93026**

   Released in August 2003 by the National Pigeon pea Breeding Programme. ICPL 93026 is an early maturing and high yielding (up 2,500 kg/ha) variety that has stable seed and grain yields. It is adapted to a wide range of environments with high market potential. It grows to a
height of 137 cm, matures in 127 days and has large cream seeds with a seed size of 17 g/100 seeds. Because of its earliness in maturity, it tends to escape the *Fusarium wilt* disease. To attain high yields, three sprays of pesticides are required during the flowering and pod filling stages.

### 2.2.6 Cowpea "Khobwe"

There are presently only two cowpea varieties have been officially released by the ATCC. These are Sudan 1 and IT82E-16.

1. **Sudan-1**
   Released in August 2003 by the National Cowpea Improvement Programme. This is a high yielding cowpea variety (1,331 kg/ha) that is susceptible to scab and *Ascachyia* at Chitedze but fairly resistant at Mbawa and resistant to these diseases at Chitala. Farmers in Malawi have been growing Sudan-1 for a long time now.

2. **IT82Erl6**
   Released in August 2003 by the National Cowpea Improvement Programme. This is a high yielding cowpea variety (1,341 kg/ha) that is susceptible to scab and *Ascachyia* at Chitedze but fairly resistant at Mbawa and resistant at Chitala.

### 2.2.7 Sunflower "Mpendadzuwa"

There is currently only one sunflower variety that has been recommended for commercial production in Malawi. This variety, HY 3037, has been developed by DARS.

1. **HV3037**
   Released in August 2005 by the National Sunflower Improvement Programme. HV 3037 is a single cross sunflower hybrid that is high yielding (>3000 kg/ha) and widely adapted to a wide range of environments. The seed is black in colour and has an oil content of 46.7%. It is highly resistant to all common sunflower diseases found in Malawi, such as *Sclerotinia* leaf spot (SLS), *Alternaria* leaf spot (ALS), and yellow blotch (YB). It has an excellent uniform head 1 Till and is early maturing. It is not easily damaged by birds because it is goose necked. The main attribute of this variety is its high yield and resistance to common sunflower diseases found in Malawi.

### 2.2.8 Cotton "Thonje"

The currently recommended cotton varieties include: MARS 92 (87) 12, Makoka 2000, FQ 902, SZ9314 and Chureza. All these have been developed by DARS.

1. **Makoka 2000 (MARS 92 (87) 12**
   Released in 2000 by the National Cotton Breeding Programme. This variety has a compact growth habit with an open canopy that facilitates effective ground spraying. The average number of days between sowing and flowering, and between flowering and boll opening (i.e., maturity) are 53 and 44 days, respectively. It has a seed cotton yield potential of over 3,000 kg/ha, and an improved ginning outturn (GOT) of 38.9%. It produces mature and fine fibres that spin a yarn of similar strength to that of the other commercial varieties when grown under the Shire valley climatic conditions. Makoka 2000 replaced EZAM 6 in the Shire Valley in 2000. Its average fiber characteristics are: 28.5 mm span length and 0.97 maturity ratios. Like all other cotton varieties, Makoka 2000 is attacked by a wide range of insect species that include: the African bollworm, aphids, red spider mites, lygus and helopetis.
2. **FQ 902**

Released in August 2002 by the National Cotton Breeding Programme. FQ902, which originates from Zimbabwe, is superior to the recommended varieties in terms of yields, fibre quality and micronaire values. It has a compact growth habit with an open canopy that facilitates easy pesticide application. It is an early maturing variety that takes 53 days to flower, 97 days to ball opening and has an earliness index of 67%. It produces large bolls (averaging 5.3 g), has high seed yield potential (>3,000 kg/ha) with an improved ginning out turn of 41%, and is tolerant to jassid attack. It is highly suitable for large-scale commercial production.

3. **SZ9314**

Released in August 2002 by the National Cotton Breeding Programme. SZ9314, which also originates from Zimbabwe, is superior to the recommended varieties in terms of yields, fibre and micronaire values. It has a compact growth habit with an open canopy that facilitates easy pesticide application. It takes 75 days to flower and 146 days to boll opening, has an earliness index of 48%, and a high yield potential (3,500 kg/ha). It has a boll size of 5.6 g and an improved ginning outturn of 43%. It is highly suitable for large-scale commercial production.

### 2.3. Horticultural Crops

New horticultural crop varieties have been developed for the following group of crops: (i) vegetables (tomato), (ii) tree nut crops (macadamia), (iii) roots and tuber crops (cassava, sweet potato and yams), and (iv) spice crops (paprika).

#### 2.3.1 Tomatoes "Matimati"

Tomato (*Lycopersicon esculentum*) is a vegetable crop that is widely grown in Malawi. Four tomato varieties have been developed and recommended for production throughout the country. These can be grown under both rain-fed and irrigated conditions.

1. **Khama (ARP-367-1)**

Released in August 2002 by the National Vegetable Improvement Programme. Khama is a firm and root knot nematode resistant variety that produces large peer-shaped fruits (4-5 per flower cluster), starts flowering after 6-7 true leaves and has an intermediate growth habit with an average of 165 seeds per fruit. It is high yielding (26-27 kg/ha) and is widely adapted throughout the country.

2. **Mbambande (ARP-367-2)**

Released in August 2002 by the National Vegetable Improvement Programme. Mbambande has very big, moderately firm round-shaped fruits (4-5 per flower cluster), starts flowering after 6-7 true leaves, has an intermediate growth habit with an average of 170 seeds per fruit, but is weak on root-knot nematodes. It is high yielding (26-27 kg/ha) and widely adapted throughout Malawi.

3. **Changu (Romittel)**

Released in August 2002 by the National Vegetable Improvement Programme that was funded by the European Union Neinatology Project. Changu is resistant to root-knot nematodes, has medium-sized and soft-skinned fruits that are cylindrically shaped (7-8 per flower cluster), starts flowering after 7-8 true leaves, determinate growth habit and an average of 56 seeds per
fruit. This is also a high yielding (26-27—kg/ha) and is widely adapted tomato variety in Malawi.

4. **Mpindulitsa (Rodade)**

Released in August 2002 by the National Vegetable Improvement Programme. Mpindulitsa has very big, firm and medium-shaped fruits that are soft-skinned and peer-shaped (4-5 per flower duster), flowers alter 4-5 true leaves, but is weak on root-knot nematodes. Mpindulitsa is high yielding (26—27 kg/ha) and is widely adapted tomato variety in Malawi.

**2.3.2 Macadamia**

Macadania (*Macadaniia integrifolia*) is a tree nut crop for which one clone, Clone 788, has been developed and recommend for commercial production in 2000.

1. Clone 788

Released August 2001 by the National Fruit Tree Improvement Programme. Clone 788 belongs to a new generation of Hawaiian macadamia clones that were imported into Malawi in 1986. This clone bears very early, is liggli yielding (more than 20 kg/tree), produces high quality kernels, and is resistant to several insect pests, including the nut borer.

**2.3.3 Cassava "Chinangwa"**

Cassava is an important source of food, cash income and for the processing industry. Over the last six years, for cassava varieties have been developed and recommended for production. These are Mkondezi, Maunjili, Silira and Yizaso.

1. **Mkondezi (MK91/478)**

Released in 2000 by the National Roots and Tuber Crops Improvement programme. This variety originates from IITA, Nigeria. It is a bitter variety that was locally selected as MIC 91/478. It has purple and hairless young leaves that turn green when mature. The stems are light brown when mature and have one to two branching levels. The roots are conical in shape with a brown outer skin, white inner skin and white fresh colour. It matures in 9 to 15 months, and produces fresh root yields of between 13,000 and 25,000 kg/ha. it has tolerance to cassava mosaic disease (CMD) and cassava mealy bag (CMG).

2. **Maunjili (CTMS 91934)**

Released in 2000 by the National Roots and Tuber Crops Improvement Programme. This variety also originates from IITA, Nigeria, which is also a bitter variety that has been selected from IITA clone TMS 91934. It has light purple young leaves with some little hair that turn green when mature. The stems are light brown when mature with two to three branching levels. Its roots are cylindrical in shape with a brown outer skin, white inner skin and a white fresh colour. It mature in 9 to 12 months after planting, and produces fresh root yields of between 15,000 to 22,000 kg/ha. It is tolerant to cassava mosaic disease (CMD) and cassava meal bag (CMG).

3. **Silira (TMS 601428)**

Released in 2000 by the National Roots and Tuber Crops Improvement Programme. Silira was originally bred at IITA as TMS 601428). This is also a bitter variety, although it is less bitter than Mkondezi and Maunjili. It has purple and hairless young leaves that turn green when mature. The stems are green with two to three branching levels. The roots are cylindrical in shape, and have a brown outer skin, white inner skin and white fresh colour. It matures in 12 to 15 months after planting; producing fresh root yields of between 10,000 to 16,000 kg/ha. It is tolerant to cassava mosaic disease (CMD) and cassava meal bag (CMG), but is susceptible to cassava green mite (CGM).
4. Yizaso (CH92/112)
Released in August 2002 by National Roots and Tuber Crops Improvement Programme.
Yizaso is a bitter, high yielding (25,000 kg/ha) variety that is tolerant to CMV and performs particularly well in areas characterized by long wet seasons. The leaves, which have little hairs, are light purple in colour when young and turn light green when mature. The petioles are red and the stems are light brown with two to three branching levels. Its roots are cylindrical in shape with a brown outer skin, and a white inner skin with a white flesh colour. Yizaso has good quality kondowole processing characteristics.

2.3.4 Sweet potato "Mbatata"
Sweet potato is increasingly being grown as a drought tolerant and security crop in Malawi. So far, four sweet potato (Ipomea batatas Lam) varieties have been developed and recommended since 2000. These are Semsa, Mugamba, Tainoni and Salera.

1. Semusa (Cemsa 74r228) (CIP 400004)
Released 2000 by the National Roots and Tuber Crops Improvement Programme. This variety was originally introduced from the International Potato Centre (CIP) as Cemsa 74-228. It has a spreading growth habit and produces green mature leaves with live moderate lobes. The vines are green in colour and mature in 5 months after planting, producing fresh root yields between 16,000 and 30,000 kg/ha. The tubers have a cream, purple tinged skin or cream fresh colour. The tubers are large and cook to a tasty floury texture, with a dry matter content of about 3.5%. It is tolerant to the sweet potato virus disease (SPVD).

2. Mugamba (CIP 440034)
Released in 2000 by the National Roots and Tuber Crops Improvement Programme. This is another variety introduced from the International Potato Centre (CIP) with a semi-erect growth habit. Its vines are green in colour, thick and do not creep much on the ground. It produces green leaves with one triangular lobe. The tubers mature in 5 months after planting, producing root yields of between 12,000 and 26,000 kg/ha. The tubers are smaller in size compared with Semusa, with a cream and orange patched skin and flesh. It has a matter content of 35%, it is floury and has a good taste. This variety is tolerant to the sweet potato virus disease (SPVD) and the sweet potato weevil (SPW).

3. Tainoni (Tainoni 57)
Released in 2000 by the National Roots and Tuber Crops Improvement Programme. This variety was originally introduced from the Asian Vegetable Research and Development Centre (AVRDC) as Tainoni 57. It has thin vines that are green in colour and a purplish lip that is characterized by an extreme spreading growth habit. Its mature leaves are green with three deep lobes, whereas the immature leaves are slightly purple. Tainoni matures between 4 and 5 months after planting, producing fresh root yields of between 17,000 and 21,000 kg/ha. The tuber skins are pale yellow in colour, and are smaller than those of Semusa and Mugamba, and tend to be more numerous. The flesh is deep yellow, hence high in b-carotene. Its dry matter content is about 30%, which is lower than that of Semusa and Mugamba. It is tolerant to the sweet potato virus disease (SVD).

4. Salera
Released in August 2002 by the National Roots and Tuber Crops Improvement Programme. Salera, originally known as CIP 1941/121, is a prolific and high yielding variety (22,000 kg/ha) that is comparable to Semusa (22,000 kg/ha) but higher than Kenya (16,000 kg/ha). It produces many medium-sized roots (6 roots per plant) compared with
Semusa or Kenya (3 roots per plant). This is a trait, preferred by traders who sale tubers by number rather than on a per weight basis. It is tolerant to major insect pests and diseases, including the sweet potato weevil. This is a sweet and mealy variety with dry matter content of 32%, which is comparable to Kenya (38%) and Semusa (35%). It can be cooked unpeeled, an advantage for commercially minded individuals.

2.3.5 Yam
During 2005, four yam (*Dioscora alula*) varieties were developed and recommended for production under smallholder farm conditions. These were screened from locally collected materials. However, these were released partially to allow for more detailed characterization of the varieties.

1. Mulanje (Accession 2)
Partially released in November 2005 by the National Roots and Tuber Crops Improvement Programme. Mulanje (Accession 2) yields between 8,000 and 35,000 kg/ha under Malawi's unimodal rainfall distribution pattern of between 4 and 5 months. However, the ideal yam (*Dioscorea alata*) climatic conditions are characterized by more than six months of high rainfall (>1,500 mm) that is well distributed over a period of 8 months or more with high temperatures (>25 °C). Mulanje, which originates from Mulanje district, has a good appearance, an average flavour and a good texture, but hard to chew.

2. Swenga (Accession 3)
Partially released in November 2005 by the National Roots and Tuber Crops Improvement Programme. Swenga (Accession 3) yields in the range of 10,000 to 21,000 kg/ha under Malawi's agro-climatic conditions. Swenga, which was collected from Thyolo district, has a good appearance, flavour and texture.

3. Malosa (Accession 4)
Partially released in November 2005 by the National Roots and Tuber Crops Improvement Programme. Malosa (Accession 4) yields in the range of 3,000 to 13,000 kg/ha under Malawi's agro-climatic conditions. Malosa, which was collected from Zomba district, has a good appearance, flavour and texture, with smooth tubers that grow quite large. During the 2002/03 crop season, Malosa was affected by *Antirracnose*.

4. Chizunga (Accession 6)
Partially released in November 2005 by the National Roots and Tuber Crops Improvement Programme. Chizunga (Accession 6) yields in the range of 11,000 to 29,000 kg/ha under Malawi's agro-climatic conditions. Chizunga, which was collected from Thyolo district, has a good appearance, flavour and texture.

2.1.6 Paprika "Papurika"
Paprika (*Capsicum annum* L.) is an important cash crop in Malawi. Only one variety has been developed and recommended for commercial production under both estate and smallholder farm conditions.

1. Mkonzakomo (Papri Queen)
Released in August 2003 by the National Spices Improvement Programme. Papri Queen is a short-lived sweet pepper herb that matures in 120 days after planting. It has high ASTA levels, averaging 298, which is 19% higher than the minimum recommended value of 250. It is adapted to a wide range of environments up to elevations of 1600 in asl in all tobacco growing areas, with yields averaging 2,500 kg/ha (ranging from 1,100 kg/ha at Bolero in Rumphi to 2,900 kg/ha at Makoka in Zomba).
2.4 Tobacco

Tobacco (Nicotiana tabacum) is the major foreign exchange earner for Malawi. It accounts for 57.4% of the country's domestic exports by value, and 10.8% of its Gross Domestic Product (GDP). There are four main types of tobacco that are grown in Malawi: (i) burley tobacco, (ii) flue cured "Virginia" tobacco, (iii) western tobacco (northern division dark fired, southern division lire-cured, and sun-air cured tobaccos), and (iv) oriental tobacco.

2.4.1 Burley Tobacco

One burley tobacco variety, Mkanachikhosi (B84-1052) has been developed and recommended for use by farmers over the last six years.

1. Mkanachikhosi (B84-1052)

Released in 2002 by the Agricultural Research and Extension Trust (ARET). This variety has a high yield potential (1,600-2,000 kg/ha) and gives good economic returns especially when grown in areas where Fusarium wilt is a problem. It has an excellent architecture, good leaf quality, and acceptable leaf chemical composition that give good flavour. It has a mean topping height of 135 cm (with 21 harvestable leaves). Mkanachikhosi is resistant to the deadly Fusarium wilt disease (Chikhosi), where it takes its name.

2.4.2 Western Tobacco

There are three types of Malawi Western Tobacco: (i) Northern division dark-fire cured tobacco, (ii) Southern division lire-cured tobacco, and (iii) Sun air-cured tobacco. So far, only one variety, MW86-57, has been developed and recommended for production.

1. MW86-57

Released in August 2003 by the Agricultural Research and Extension Trust (ARET). This is a semi-erect and semi-compact variety that produces a high proportion of dark and light-coloured cured leaf that is demanded by the trade. It is medium ripening and has a yield potential of 2,500 kg/ha producing a dark green leaf that cures to a balanced dark and light leaf. It is resistant to Alcemalia, tobacco mosaic virus, and Fusarium wilt but it succumbs to all other known soil borne diseases common in Malawi. It has acceptable leaf chemical composition that is within the critical levels that give good flavour. The main advantage of this variety is its tolerance to Alcemalia brown rust.

2.5 Tea

Tea (Camellia sinensis L.) is the second most important foreign exchange earner after tobacco. Tea is mainly adapted to the high altitude areas with well-distributed annual rainfall exceeding 1,250 mm per year. So far, work has concentrated on the development of tea field clones and tea rootstock clones.

2.5.1 Tea field clones

During the past few years, new clones, resulting from artificial and open pollination, have been selected for both tea-making quality and field performance (yield). Some four field clones have so far have been released and recommended.

1. PC 175

Released in 2001 by the Tea Research Foundation of Central Africa (TRF). This is a high yielding progeny done with rooting ability and vigorous nursery growth. It has a high total value when compared with SFS 150 and PC 180. It quickly recovers from drought, and is highly suitable for the Mulanjc-Thyolo highlands.

2. PC 184
Released in 2001 by the Tea Research Foundation of Central Africa (TRF). This progeny clone has a high yield potential under both rain-fed and irrigated conditions. It has higher quality potential and total value than SFS 150. It is fast growing even in the cool season, and is highly recommended for high rainfall areas.

3. PC 198
Released in 2001 by the Tea Research Foundation of Central Africa (TRF). This is a high yielding progeny clone that is tolerant to drought and performs better than PC 108 and SFS 150 in terms of shoot growth and good cool season growth. It also has so far; more succulent, easier to pluck shoots, and has higher quality and total value than SFS 150.

4. PC 213
Released in 2001 by the Tea Research Foundation of Central Africa (TRF). This progeny clone has good rooting potential, fast shoot growth, high degree of drought tolerance, establishes well under both rain-fed and irrigated conditions, and produces higher yield than SFS 150 and PC 108. It is generally free from insect pests and diseases, and has higher quality potential than SFS 150. It is suitable for high altitude areas with marginal rainfall.

2.5.2 Tea rootstock clones
Four tea rootstock clones have so far been developed, released and recommended for commercial production. These have been selected because they are invigorating, drought tolerant and greatly boost the yields of high quality clones.

5. RC 7
Released in 2002 by the Tea Research Foundation of Central Africa (TRF). This rootstock clone was originally selected as a field clone but was not released because it produces small shoots that required a lot of labour to harvest. It has a very invigorating root system that boosts the yields of PC 105 and PC 108 by more than 30%, exhibiting good congeniality.

6. RC 13
Released in August 2002 by the Tea Research Foundation of Central Africa (TRF). This rootstock-clone was selected on the basis of exhibiting a high degree of drought tolerance and vigorous growth. RC 13 boosts the yield of PC 105 and PC 108 by more than 20% when compared with the standard rootstock clone RC 2.

7. RC 15
Released in August 2002 by the Tea Research Foundation of Central Africa (TRF). This rootstock clone was originally selected as a field clone because of its vigorous growth and ease of vegetative propagation, but was not recommended for production because it produces average quality tea. However, when PC 105 and PC 108 scion clones are grafted on RC 15 rootstock clones, they have consistently produced higher yields during drought periods. For example, during the 2000/01 drought year, RC 15 increased the yields of PC 105 and PC 108 by 30 and 22%, respectively, whereas RC 2, increased the yields of these by 13 and 4%, respectively.

8. RC 16
Released in August 2002 by the Tea Research Foundation of Central Africa (TRF). This rootstock clone was originally selected as a field clone but was not recommended because of leaf poise and low quality tea potential. However, RC 16 grows vigorously and is easy to propagate. In drought years, RC 16 boosts the yields of PC 105 and PC 108 by more than 40 and 20%, respectively.
Chapter 3: Crop and Livestock Production Technologies

3.1 Introduction
Since 1998, the Agricultural Technology Clearing Committee (ATCC) was charged with the function of approving and releasing all agricultural technologies developed and recommended for use by farmers in Malawi. Thus, besides crop varieties, the ATCC is also responsible of releasing all agricultural technologies, including crop and livestock production technologies, and agricultural processing and utilization technologies. This section presents some of the crop and livestock production developed for: (i) cereal crops, (ii) horticultural crops and (iii) livestock.

3.2 Cereal Crops Production Technologies
Cereal crop production technologies have been developed for maize and rice. These have focused on plant protection in the field and grain protection in storage, fertilizer management, and soil fertility improvement and enhancement.

3.2.1 Maize
Maize production technologies have been developed for: (i) seed dressing, plant and grain protection in the field and in storage, and soil fertility amelioration under smallholder farm conditions.

1. Application of Actellic Super Dust and Bifenthrin to control the larger grain borer (LGB)
Released in September 2000 by the National Crop Storage Improvement Programme. An application of Actellic Super (Pirimiphos methyl 1.6. %+0.3% Permethrin) and/or Bifenthrin 0.1% dust at the rate of 50 g to 90 kg shelled grain, or 50 g to 2 bags of 50 kg shelled maize, which has been thoroughly mixed with maize is elective in controlling the larger grain borer, LGB (Prostephanus truncatus), one of the most destructive insect pests of maize in storage. LGB is widely distributed in Malawi, and is a serious and great threat to stored maize. To control this insect pest, an integrated post-harvest management strategy is recommended that involves the use of cultural, biological and chemical control measures, such as the application of Actellic Super and Bifenthrin dusts. Since this insect pest causes less damage to unshelled grain maize than maize on the cob, it strongly recommended that farmers should shell their maize. The maize should be thoroughly and properly dried before treatment.

2. Application of Gaucho-T to control maize steak virus (MSV) disease
Partially released in November 2001 by the National Crop Storage Improvement Programme. An application of Gaucho-T to seed maize at the rate of 5 g/kg seed is effective in controlling Cicadulina leaf hoppers that attack maize early in the season. Gaucho-T is an insecticide that contains both imidacloprid and thiram as active ingredients. Imidacloprid, a nitroguanidine insecticide is characterized by relatively low mammalian toxicity (LSD50 value 450 mg/g) that is classified as moderately hazardous, but shows high levels of toxicity to a range of insects and considerable systemic activity via the plant tissue.
Imidacloprid belongs to a new family of active ingredients, the nitroguanidincs, which are also known as nitromethylene insecticides. The virus (maize streak virus, MSV), that incites the disease is persistently transmitted by Homopteran insects of the genus Cicadulina, with C. mabala, C. storeyi and C. parazcae as the commonest species. It is these Cicadulina leaf hoppers that are effectively controlled by Gaucho-T, which is both an insecticide and fungicide. It acts both as a stomach and contact insecticide and protects maize from early season insect pests. As a seed treatment, Gaucho-T puts the active ingredient in the direct vicinity of the seed, so that direct exposure to the environment is very minimal.

3. Application of Shumba Super to control crop storage insect pests
Released in 2002 by the National Crop Storage Improvement Programme in collaboration with Syngenta of Zimbabwe. An application of Shumba Super is effective in controlling insect pests of crops in storage. Shumba Super is a combination of two insecticides: 1.0% Fenitrothion and 0.13% Deltamethrin. Deltamethrin is a pyrethroid that controls woodborers, such as the larger grain borer (LGB), whereas Fenitrothion is an organophosphate that controls other storage insect pests, such as the maize weevil. It is recommended to apply Shumba Super at the rate of 50 g of chemical dust to 2 x 50 kg bags containing shelled produce, or 1 bottle of Shumba Super dust (200 g) to 8 x 50 kg bags of shelled produce. When using Shumba Super, farmers should remember the following: (i) applying Shumba Super to crops that will be stored for more than 3 months, (ii) checking the produce, re-treating or re-drying after application, if the situation dictates so, (iii) wearing protective gear when applying Shumba Super, (iv) washing the hands and face after applying Shumba Super, and (v) storing Shumba Super in a cool dry place that is out of reach of children and pets.

4. Application of Super Guard Dust and Super Guard 50EC to control storage insect pests
Released in August 2003 by the National Crop Storage Improvement Programme. An application of Super Guard Dust (1.6% Perimiphos methyl + 0.4% Permethrin) to stored maize is just as effective as applying Actellic Super (1.6% Pirimiphos+0.3% Permedirin) in controlling common storage insect pests, such as LGB (Prostephanus truncatus) and Sitophilus ssp. This should also be applied at the rate of 50 g of chemical dust to 2 x 50 kg of shelled maize. The release of this chemical product gives farmers a wider choice of chemicals to choose from to control storage insect pests. The other chemicals available to farmers include Actellic Super, Shumba Super and Grain Dust

5. Application of Gaucho 70ws to maize seed to control early season insect pests
Released in August 2003 by the National Maize Plant Protection Improvement Programme. An application of Gaucho 70ws at the rate of 5 g product per 5 kg maize seed as a dressing is effective, convenient and economical in controlling insect pests that attack maize early in the season (0-12 weeks after planting). Gaucho is effective in controlling insect pests such as aphids and leafhoppers of the genus Cicadulina, which are the vectors that transmit maize streak virus (MSV) in late-planted dimba maize. Thus, by controlling these insect pests, Gaucho 70ws is also effective in controlling MSV, a disease of great economic importance for dimba maize production. This chemical product is now fully released following its partial release in 2002. Additionally, this chemical product has already been released for use as a cotton seed dressing.

6. Application of Chikara Super to control storage insect pests
Released in August 2004 by the National Crop Storage Improvement Programme. An application of Chikara Super at the rate of 50 g of chemical dust to 2 x 50 kg bags containing shelled product, or one bottle of Chikara Super dust (200 g) to 8 x 50 kg bags of stored produce, is effective in controlling storage insect pests. Chikara Super is a combination of 1.7% Fenitrothion, which is an organophosphate that controls storage insect pests and 0.3% Pernicthrin, which is a synthetic pyrethroid that controls woodborers. Fenitrothion has an acute
7. Application of Deltaphos to control storage insect pests
Released in August 2004 by the National Crop Storage Improvement Programme. An application of Deltaphos at the rate of 50 g of chemical dust to 2 x 50 kg bags containing shelled produce, or one bottle of Deltaphos dust (200 g) to 8 x 50 kg bags of stored produce is effective in controlling storage insect pests. Deltaphos is a combination of 1.0% pirimiphos methyl, which is an organophosphate that controls storage insect pests and 0.13% Deltamethrin, which is a synthetic pyrethroid that controls woodborers. Deltamethrin has an acute oral LD₅₀ of 135 to more than 5,000 mg/kg and has a mild skin irritant, whereas Pirimiphos has an acute oral LD₅₀ of 2,050 mg/kg and has an inhalation and ingestion hazard that has been classified as toxic. The oral LD₅₀ for rats is more than 5,000 mg/kg. Deltaphos is effective in controlling most storage insect pests, including the notorious LGB, and has been recommended to broaden the range of insecticides available for use by farmers in Malawi. The other recommended insecticides include: Actellic Super, Shumba Super, Grain Dust, Super Guard and Bifenithrin.

8. Strategies for witchweed (Striga asiatica) suppression and field hygiene
Released in June 2000 by the National Maize Improvement Programme. Several management strategies for controlling witchweed in cereal crops for the whole farm or portions of farms have been developed. Witchweed is the common name for the parasitic weed species known as striga. In Malawi, striga asiatica (locally known as kaufti) is the most wide-spread, and it parasitise cereals, such as maize, sorghum, millet and rice. Witchweed grows on the roots of host plants where it draws its water and nutrients, causing a toxic effect that results in stuntedness and wilting of the host plant even before the witchweed emerges above the ground. Seed of witchweed may remain dormant for a period of more than 10 years, but may be triggered at any time by a stimulant, known as strigal that is naturally produced by the roots of host plants, provided it is also exposed to warm temperatures (22-30 °C) and moist conditions for about 10 to 21 days. After attaching itself to the host plant, and sharing growth variables (water, nutrients and sunlight), it greatly reduces the yield of the host plan, so that control or suppressive measures are required to deal with this obnoxious weed. These include: (i) preventive measures, (ii) suppressive measures, and (iii) good crop husbandry practices. The preventive measures include the stopping of: (i) seed multiplication, (ii) seed movement, and (iii) use of contaminated seed, whereas the suppressive measures include the use of: (i) mineral fertilizers and organic manures, (ii) intercropping systems, (iii) crop rotations, (iv) catch crops, (v) trap crops, and (vi) pesticides and herbicides. The good crop husbandry practices include (i) early planting (ii) timely weeding, and (iii) use of improved crop varieties. Witchweed infestation is quite common in many parts of Malawi. The situation is aggravated by droughts and low soil fertility, especially on smallholder farms.

9. Application of herbicides and fertilizers to control witchweed (Striga asiatica) in maize
Released in August 2002 by the National Maize Improvement Programme. An application of herbicides, while effective in controlling weeds, is also effective in suppressing witchweed in maize. In particular, an application of Dual, a pre-emergence herbicide, into the soil at the rate of 2.2 litre/ha before planting maize is effective in suppressing witchweed. At this rate Dual controls weeds and suppresses the emergence of witchweed. This is useful for individual farmers or institutions wishing to effectively control witchweed on prime land. For example, prison farms, Research station, training centers, irrigation schemes or productive farmers.
adopting improved crop management practices, such as those under the Sasakawa G2000-Malawi Government partnership programme. It should be noted that witchweed continues to be a major constraint to maize production in Malawi, especially under low soil fertility conditions on smallholder farms, a situation that is now compounded by frequent droughts.

10. **Strategies for winter maize production in *dambos* and along river valleys**

   **Released in June 2000 by the National Maize Improvement Programme.**

   The growing of maize in the dry season under residual soil moisture, or irrigation, is now very common along the lakeshore areas, river valleys, and in *dambos* throughout the country. This is what is referred to as *dimba* maize. Currently, some 296 hectares can potentially be grown to *dimba* maize. To increase *dimba* maize production, a package of production practices has been developed. This production package comprise: (i) maize varieties, (ii) time of planting, (iii) plant population density, (iv) depth of planting, (v) plant spacing, (vi) rate of fertilizer nitrogen application, and (vii) pest and disease control strategies. Both hybrid and open pollinated maize varieties (OPV) can be grown. Presently, these include: DK 8031, DK 8041, DK 8071, SC 403, SC 407, SC 621, SC 627, SC 713, SC 715, PAN 6193 (Katswiri), and Masika. In addition, any variety that is resistant or tolerant to maize streak virus (MSV) can safely be grown under residual moisture conditions in the *dimbas*. Hybrid and OPVs yield about 3,500 and 3,000 kg/ha, respectively under the normal plant population density of 37,000 plants per ha. Higher yields are expected for higher planting densities, such as 44,000 plants per ha. Time of planting *dimba* maize varies from area to area because it depends on available soil moisture and prevailing air temperatures. However, for warmer areas, such as along the Lakeshore plain (e.g., Karonga and Salima) or the Shire valley, *dimba* maize should be planted towards the end of May to early June. For cooler areas, such as the Viphya plateau, planting towards the end of June gives better and higher yields. *Dimba* maize should be planted on flat and well-prepared land on rows spaced 90 cm apart and 90 cm between planting stations, and three seeds per station to give a plant population density of 37,000 plants/ha. If a higher plant population is used, farmers should reduce the row spacing to 75 cm, and the plant one plant per station at spacing to 25 cm apart, to give 44,000 plants per hectare. The planting depth should vary with soil moisture conditions at planting time, but should not be more than 40 cm deep. The holes should be covered with 2 cm of soil soon after planting to reduce soil moisture loss by evaporation. All maize varieties recommended for *dimba* cultivation respond positively to fertilizer nitrogen application on all types (hydromorphic and/or alluvial soils) that characterize *dimba* maize growing environments. An application of 40 kg N/ha as urea or CAN should applied on *dimba* maize to optimize grain yields, regardless of the soil type: hydromorphic or alluvial. Generally, *dimba* maize responds better to fertilizer application when it is planted after a rain-fed crop of rice. *Dimba* maize also greatly responds to the application of organic manures such as compost, chicken, and cattle manures. Apply these at the rate of between 5 and 10t/ha depending on quality and availability. Apart from processing maize into Hour for the preparation of the traditional *N'siina*, *dimba* maize is increasingly consumed on the cob as a snack when cooked green or roasted. During the dry season (winter) months, *dimba* maize sells quite fast, and at a relatively high price, making *dimba* maize a high value cash crop.

11. **Application of *Tithonia diversifolia* to increase maize yields**

   **Released in June 2000 by the National Maize Improvement Programme.**

   An application of 3,000 kg/ha of *Tithonia diversifolia* green leaf manure is sufficient to increase maize grain yields to more than 3,500 kg/ha under good crop management practices. *Tithonia* is an agroforestry tree species that has the ability to produce huge quantities of leaf biomass of up 500 kg/ha during the first year of planting and to more than 10,000 kg/ha by the second year. The fresh leaf N content is high (>3.5%) and the nutrients levels of other elements is also relatively good (0.5% P and 0.4% potassium), indicates that an application of *Tithonia diversifolia* leaf biomass
into the soil will add considerable amounts of N, which can later be taken-up by a growing maize plant. *Tithonia deveisiolii* is widely available in Malawi. It grows in the wild and near homesteads. Documented evidence estimates that *Tithonia* is widely distributed in Malawi. As the case is with all low-input, low-cost agricultural technologies, farmers are advised to apply *Tithonia* leaf biomass in conjunction with inorganic fertilizers to optimize maize grain yields. The methods of *Tithonia* biomass application are the same as those for inorganic fertilizers, i.e., broadcasting, (lolloping or banding along the ridge.

12. **Application of green legume manures to improve soil fertility and maize yields** Released in August 2001 by the National Maize Improvement Programme. Growing maize after *Mucuna pruriens*, *Crotalaria juncea* and *Lablab purpureus* green leaf biomass, which is either incorporated early or late, significantly increases maize grain yields compared with the growing of maize continuously without the application of green manures. Maize grain yields are increased further when inorganic fertilizer N is applied at the rate of 35 kg N/ha in combination with these green legume manure. This shows that the three green leaf manures have the potential to increase soil fertility and maize yields when incorporated either as sole green manures or when combined with inorganic fertilizers. Legume crops have the potential to fix atmospheric nitrogen through the process of Biological Nitrogen fixation (BNF). The fixed nitrogen is for the crops' use. However, when leaf biomass is added to the soil, the N accumulated in the leaf is available to the succeeding cereal crop that responds positively to the added nutrients. These three legumes produce more than 4,000 kg/ha leaf biomass, whether they are incorporated early or late. The leaves of these have leaf N contents of more than 4% at flowering time. This translates into more than 160 kg N/ha that can potentially be released and made available to the succeeding cereal crops.

An early or late application of these green manures has resulted in the production of maize yields that are in excess of 3,000 kg/ha, which is a significant shift from the usually quoted national maize grain yield of 1.1 kg/ha. Thus, the application of green legume manures has great potential to increase maize yields even doses as low as 35 kg N/ha of mineral fertilizers are applied. Thus, the recommended strategy is to apply as much as possible of the green leaf manure in combination with as little as possible of the inorganic fertilizer N that optimizes maize grain yields.

13. **Application of 2000 kg lime per ha to increase maize yields in acidic soils** Released in November 2005 by the National Soil Fertility Improvement Programme. An application of 2,000 kg/ha lime to maize grown on acidic soils is effective at increasing grain and dry matter yields of maize. Acid soils are mainly found in areas characterized by high total rainfall (>900 mm per year) and low soil pH levels (<5.5), such as on vast areas on Mulanje, Dedza, Misuku and Viphya plateaus. Agricultural lime needs to be applied on newly prepared ridges, which have been split in the middle. The lime is incorporated into the ridge, and maize is planted at the recommended plant density and following all the recommended agronomic and crop husbandry practices as outlined in the Guide to Agricultural Production and Natural Resources Management (GAP) in Malawi. The best source of local agricultural lime in Malawi is near Chuzi in Chikwawa district and Uliwa (Clilumba) in Karonga district. Other lime deposits are found in many parts of Malawi, especially Ntcheu and Balaka districts.
3.2.2 Rice
Four rice production technologies have been developed and recommended. These have mainly focused on fertilizer urea management, weeding frequency, and plant spacing under irrigated conditions.

1. Methods of applying urea to irrigated rice
Released June 2002 by the National Rice Improvement Programme. An application of urea, by
broadcasting, and incorporating at 5 cm depth before transplanting rice, have been found to
greatly increase rice yields under irrigated conditions. Rice (Oryza sativa L), the second most
importance cereal food crop in Malawi, is adapted to a wide range of altitudes ranging from
50-1,000 m asl along the lakeshore plain, lake Chilwa plain, the Shire highlands and the lower
Shire valley. It is grown under both rain-led and irrigated conditions. In these agro-ecologies,
the annual mean temperatures range from 22-25°C and rainfall varies from 660-2,421 mm per
year. Although rice is essentially adapted to heavy clays, it equally does well on a wide range of
soil types, including calcimorphic alluvial soils that have soil pH values ranging from 5.8-8.5.
However, the yields of rice per unit area are very low, mainly owing to a multitude of
production constraints that include: low soil fertility, poor crop husbandry and agronomic
practices, insect pests, diseases and weeds, and poor harvesting and drying methods, among
many others. For the present, we focus on the methods of applying 80 kg N/ha and 25 kg P2O5
/ha, to achieve rice grain yields of up to 6,000 kg/ha. Urea is applied as a basal and top dressing.
For basal dressing, apply 25 kg urea/ha before transplanting, and 100 kg (2 bags of 50 kg each)
of 23:21:0+4S per ha soon after puddling the soil, but before transplanting the rice. Broadcast
the fertilizer by hand and incorporate it to a depth of 5 cm soon alter application to achieve
optimum uniformity. Fertilizer application, puddling and incorporation should be done when
there is less than 1 cm of standing water. After transplanting, increase the water level to more
than 1 cm. For top dressing, apply 100 kg (2 bags of 50 kg each) urea per ha 40 days alter
transplanting. This should be done when the leaves are relatively dry (to avoid scorching), and
more than 5 cm of water standing on the plot. Dividing the field into small plots of about 10 x
10 m (with 30 cm wide bunds or leaves ensures that the right amount of fertilizer and water are
applied to the field. Mix the fertilizer with 3 cm of top soil (also called scuffling) to ensure
uniform fertilizer application to the plot.

2. Frequency of weeding rice to optimize grain yields
Released in August 2003 by the National Rice Improvement Programme. Weeding rain- led rice
times, 2, 4 mid 8 weeks after seedling emergence, is effective in controlling weeds,
increasing rice grain yields and optimizing net benefits to the farmer. This weeding regime is
more effective in controlling weeds those two weedings at 2 and 4 weeks, two weedings at 2 and
5 weeks, or one weeding 5 weeks only. Thus, it is recommended that farmers should keep their
rice fields weed-free at all the times by weeding their fields three times if they want to optimize
grain yields and returns to investment.

3. Basal dressing urea at 6.5 cm depth to optimize grain yields of irrigated rice
Released in August 2003 by the National Rice Improvement Programme. Incorporating
fertilizer urea at 5 cm soil depth at basal dressing time is effective in increasing rice grain yields
and optimizing net benefits to the farmer when compared with the currently recommended
depth of incorporating fertilizer urea at 23 cm soil depth. This method is less labour demanding
but more effective than applying fertilizer urea on the surface. Hence, the earlier
recommendation of incorporating fertilizer urea at 23 cm soil depth is now replaced with
applying fertilizer urea at 5 cm soil depth.
4. **Application of fertilizer urea to Nunkile (Pussa 33) rice under irrigated conditions**

Released in August 2003 by the National Rice Improvement Programme. An application of (i) 240 kg N/ha at Lifuwu and Domasi; (ii) 160 kg N/ha at Lufilya, Hara and Mkondezi, and (iii) 120 kg N/ha at Kasinthula; are effective in optimizing Nunkile grain yields and economic returns to the farmer. This recommendation further indicates that the soils at Kasinthula are of better fertility than either at Lifuwu, Domasi, Lufilya, Hara or Mkondezi. Since Vyawo and Mtupatupa have similar grain yields with Nunkile, the same fertilizer rates should be applicable to these varieties. Further, the same plant spacing of 23x15 cm should equally be applicable to this variety.

### 3.3 Fibre Crops Production Technologies

Fibre crops production technologies have been mainly been developed for cotton, since it is one crop that is attacked by insect pests throughout its growth period.

#### 3.3.1 Cotton

The recommended cotton production technologies have mainly focused on seed dressing to protect cotton from early season sucking insect pests, weed control, insect pest control, and methods and equipment for applying chemicals.

1. **Application of Gaucho 70WSS to control aphids and other early season sucking insect pests in cotton**

Released in August 2001 by the National Cotton Improvement Programme. Gaucho 70WSS which is also known as Imidocloprid, is a nitroguanidine insecticide that is effective in controlling aphids and other insect pests that attack cotton early in the season. Imidacloprid belongs to a new family of active ingredients, the nitroguanidines that are also known as nitromethylene insecticides. These chemicals are characterized by relatively low mammalian toxicity (LSD50 value of 450 mg/g and is classified by the WHO as moderately hazardous), while showing high levels of toxicity to a range of insect pests and considerable systemic activity via the plant tissue. Imidacloprid is a colourless crystalline solid with a slight characteristic odour. In Malawi, and elsewhere in Africa, Imidacloprid is sold as Gaucho, a product that contains 700 g/kg active ingredient (a.i.) and is in powder form mixed with a blue dye that is packed in plastic bags weighing 120 g each. Farmers in Malawi are advised to apply Gaucho as seed cotton dressing at the rate of 5 product/kg seed to control aphids and other early season sucking insect pests that attack cotton for a period of up to twelve weeks after planting.

2. **Application of Decistab to control the Africa bollworm in cotton**

Released in August 2001 by the National Cotton Improvement Programme. Decistab is a deltamethrin that is formulated in pre-weighed tablet form that easily disperses in water. Deltamethrin (Decis 2.5 EC) is a pyrethroid with an LSD50 value of 135 and has been classified as moderately hazardous by the World Health Organization (WHO). Decistab is recommended for application to cotton at the rate of 5 g a.i./ha for the control of the Africa bollworm (*Helicoverpa armigera*). This is achieved by mixing one 0.5 g a.i. tablet of Decistab in 14 litres of water. Because the tablet quickly disperses in water, farmers now have access to an insecticide that they can use without directly handling it as the case is with emulsifiable concentrates, wettable powders or dusts which are prone to pulling and drift spillage, and may easily contaminate the skin.

3. **Application of Karate 3.75WG to control the African bollworm in cotton**

Released in August 2001 by the National Cotton Improvement Programme. Karate is a proprietary (trade) name for the pyrethroid active ingredient (a.i) Lambda-Cyhalodrin. The emulsifiable concentrate (EC) formulation, Karate 5 EC, is recommended for the control of the Africa bollworm on cotton. The manufactures have recently developed a water dispersible...
granule (WG) formulation of Lambda-Cyhalothrin, Karate 3.75\textsuperscript{WG}. The new formulation minimizes poisoning hazards of the user because, unlike the EC formulation, the WG formulation does not readily penetrate the skin. The granules also do not pull or drift as readily as powders or dust formulations, since new formulation is also packed in a pre-weighed sachet containing enough granules for one tank. Further, this minimizes contaminating farmers with the chemical who often simply pour the contents of the sachet into the mixing bucket without handling the chemical properly. The sachet is opened with a pair of scissors or a sharp razor and then the contents are poured into the mixing bucket containing a small quantity of water. The contents are then stirred and more water is added to dilute to the recommended concentration. Pour the pesticide mixture in to a sprayer tank through a strainer, and spray as recommended. Although Karate 3.75\textsuperscript{WG} is recommended for the control of the Africa bollworm, it also controls red spiny bollworms and leaf chewing insects. All pyrethroids induce the multiplication of red spidermite and aphids and resistance to all exposed insect pests. Apply a maximum of four applications in one crop growing season. Karate 3.7.5\textsuperscript{wc} should be applied at the rate 11.4 g a.i./ha using a knapsack, sprayer with a tail boom. Pour the contents of a 16 g sachet into 14 litres of water, mix thoroughly, and using a spinning disc, very low volume sprayer, such as the Ulva, apply the mixture as recommended. When applying, the operator should walk at a brick speed of about 1 metre per second. However, it should be remembered that all pesticides are harmful to human beings, livestock, wildlife, and to the environment in general. Users should wash their hands, the sprayer, mixing buckets and any contaminated containers and clothing idler handling any type of pesticide. Do not eat, drink or smoke tobacco before washing your hands. Do not leave contaminated containers and empty sachets lying on the soil surface after spraying to prevent contamination. Bury all empty sachets in the soil.

4. Application of the Ulva+Sprayer to control insect pests in cotton

Released in June 2000 by the National Cotton Improvement Programme. The Ulva+ Sprayer is an economic battery operated hand-held spray disc operator that has recently been recommended for use as an alternative to the other recommended sprayers: (i) the knapsack sprayer mounted with a tailboom (the Jacto) and (ii) the battery-operated spinning disc hand-held sprayer (the Turbair-X). The Ulva+ Sprayer, which also requires to be handled with care, has been designed to overcome most of the disadvantages associated with the knapsack and Turbair-X sprayers. It uses small quantities of water (not more than 20 litres/ha), is light with negligible drudgery on part of the farmer, has low pesticide wastage as most of the pesticide lands on the target pest and has a low rate of battery power consumption. The Ulva+ Sprayer consists of four major parts: (i) a tank, which is a 1 litre bottle, for holding the pesticide mixture, (ii) a motor for spinning the disc, (iii) a disc for breaking the pesticide mixture into small uniform-sized droplets, and (iv) a handle, which also holds the battery. To operate the Ulv+Sprayer, load 8 size D torch cells into the battery holder and fasten the battery cover in place, mix the pesticide with water to make a 1 litre pesticide mixture and pour the contents in the tank, hold the bottle in the upright position, turn on the motor using the switch on the handle, and when the disc rotation has attained its maximum speed, invert the bottle and start spraying. Apply a two-ridge swath while holding the nozzle at 30 cm above the top of the canopy for a cotton crop that is less than 50 cm, and when the crop is more than 50 cm tall, use a 1-ridge swath holding the nozzle at 15 cm above the top of crop canopy. Walk at a speed of about 1 metre/second (walking at a brisk speed, i.e., kuyenda ndamtla), and the disc head should be held directly above the furrow adjacent to the spray operator. After each spraying trip (on refilling), cover the spinning disc by unscrewing the bottle and then putting it on a non-dusty surface, and alter refilling, screwing the bottle back and carrying the sprayer in an upright position. After a day's spraying programme, fill the tank with clean water, swirl and empty in a pit, at least three times, fill the tank with clean water, screwing bottle to the sprayer, and spraying in a pit to rinse...
the restrictor and spinning disc. Wipe the handle, disc cover and the bottle with a moist clean cloth, and dry the sprayer in the shade and store it in a cool dry place out of reach of people (especially children) and livestock.

5. **Application of cotton production package comprising Cruiser, Ingram Combi and Polytrin C to increase cotton yields and quality**

Partially released in August 2002 by Chemicals and Marketing Company Limited in collaboration with the National Cotton Improvement Programme. A new cotton production package, comprising Cruiser, Ingram Combi and Polytrin C, has been recommended for the control of early season insects pests, weeds, and late season insect pests to boost cotton yields in Malawi. This cotton production package is able to increase cotton yields up to 2,500 kg/ha, which is a significant shift when compared with the use of currently recommended production packages that yield between 700 to 800 kg/ha. This new package comprise: (i) Cruiser 70WS (a seed dresser for the control of early season (0-8 weeks) insect pests), (ii) Ingram Combi (an herbicide for the control of weeds during the whole season), (iii) Polytrin C (an insecticide for the control of insect pests from flowering to ball splitting).

6. **Application of Marshal (carbosulfan) to control the cotton aphid (Aphis gossypii)**

Released in 2002 by the National Cotton Improvement Programme. An application of Marshal 25EC (Carbosulfan) to cotton during the growing period is effective in controlling the cotton aphid (Aphis gossypii), an insect pest that damages cotton during its growth period. The damage caused by aphids include: (i) sap sucking that results into leaf curling, stem tips crinkling and the stunting of plants, (ii) production of honeydew that drips on the lower leaves of the plant, and (iii) development of black fungus, known as sooty mould, which grows on the honeydew. Marshall 25 EC, which is a carbamate, should be applied at the rate of 54-268 g active ingredient per hectare. The volume of spray mixture applied ranges from 50 to 280 litres per ha depending on the size of the crop and the severity of the pests, when 1 to 4 pairs of nozzles are opened. When using a knapsack sprayer with a tailboom, dilute 60 ml into 14 litres of water, whereas if a spinning disk sprayer is used, dilute 60 ml in 1 litre of water. It should always be remembered that pesticides are harmful to humans, livestock, wildlife and the environment, so that care should always be taken when using these. All users should: (i) not store pesticides together with foodstuffs, (ii) wash hands, the sprayer, buckets and any contaminated containers, including clothing, alter handling the pesticide, (ii) do not drink, eat or smoke tobacco before washing hands, (iv) do not leave contaminated containers and empty bottles lying on the ground idler spraying to prevent livestock, wildlife, children and untrained persons from being contaminated, and (v) bury all empty bottles that contained the pesticide into the soil.

7. **Application of Ingran® Combi 500 EC to control weeds in cotton**

Released in 2003 by the National Cotton Improvement Programme. An application of Ingran® Combi 50 EC at the rate of 2.5 l/ha (for light-textured soils) and 3.0 l/ha (for medium- and line-textured soils) is both economical and effective in controlling weeds in cotton fields. Ingran® Combi 500 EC is a brownish emulsifiable concentrate that is flammable and slightly hazardous (WHO Class III). It contains 333 g/l of metolachlor and 167 g/l of terbutryn as active ingredients. Terbutryn belongs to a group of trainers. Ingran® Combi 500 EC is pre-emergence herbicide that should be applied during or after planting, but before weeds and crops emerge. It is effective in controlling most annual grasses and annual broad-leaved weeds that are common in Malawi, including the noxious *Eleusine indica*, *Bidens pilosa* and the onion grass. It should be remembered that Ingran® Combi was partially released in 2002 as part of "a new cotton production package", to
control weeds in cotton, comprising: (i) Cruiser 70\(^w\) (a seed dressing for the control of early season insect pests), (ii) Igran Combi\(^R\) (for the control of weeds), and (iii) Polytrin C (for the control of insect pests from flowering to ball filling).

8. Application of Cruiser 350 FS to seed cotton to control aphids and other early season sucking insect pests in cotton

Released in 2003 by the National Cotton Improvement Programme. An application of Cruiser 350 FS, as a seed dressing, at the rate of 100 g a.i. per 100 kg cottonseed is effective in controlling the cotton aphid and other early season sucking insect pests for a period of up to 8 weeks after planting. Cruiser 350 FS is a thiamethoxam pesticide that belongs to a pesticide group known as nitroguanidines. Nitroguanidines have a different mode of action when compared with organophosphates, to the group, that the recommended dimethoate belongs. It has the following characteristics: (i) an acute oral toxicity (rat) LD\(_{50}\) of 2918 mg/kg b.w. (ii) an acute dermal toxicity (rat) LD\(_{50}\) of >500 mg/kg, (iii) an acute inhalation toxicity (rat) LD\(_{50}\) of 4 h >4.02 mg/1, and (iv) an acute skin irritation (rabbit) that is non-irritant. The release of Cruiser 350 FS is an important addition to the range of pesticides used in the control of the cotton aphid and other early season sucking insect pests. It should also be remembered that Cruiser was partially released in 2002 as part of "a new cotton production package" comprising: (i) Cruiser 70\(^w\) (a seed dressing for the control of early season insect pests), (ii) Igran Combi (for the control of weeds), and (iii) Polytrin C (for the control of insect pests from flowering to boll filling).

9. Application of Polytrin C 440 EC and Fantom C 315 EC to control sucking, leaf eating, and bollworm insect pests in cotton

Released in 2003 by the National Cotton Improvement Programme. An application of Polytrin C 440 EC and Fantom C 315 EC are effective and economic in controlling early- and mid-season sucking and leaf eating insects, including cotton bollworms. The recommended application rates, following scouting-based spraying regimes, are as follows: (a) for seed cotton treated with Cruiser 350 S at the rate of 100 g a.i./100 kg seed, apply (i) Polytrin C 440 EC at the rate of 1000 ml/1, or (ii) Fantom C 315 EC at the rate of 750 ml/ha, and (b) for seed cotton that is not treated, apply: (i) Fantom C 315 EC at the rate of 750 ml/ha, or (ii) Fantom C 315 EC at the rate of 1000 ml/ha, if it is affordable. Please note that Polytrin C 440 EC is not recommended for application on undressed seed, and was partially released in 2002 as part of "a new cotton production package" comprising: (i) Cruiser 70\(^w\) (a seed dressing for the control of early season insect pests), (ii) Igran Combi (an herbicide for the control of weeds), and (iii) Polytrin C (a pesticide for the control of insect pests from flowering to boll filling).

Polytrin C 440 EC, which is classified as moderately hazardous (FAO Class II), has the following characteristics: (i) an oral acute toxicity (rat) LD\(_{50}\) of 7000 mg/kg, (ii) an acute dermal toxicity LD\(_{50}\) >4000 mg/kg, and (iii) an acute toxicity to fish ECT\(_{50}\) of about 0.03 mg/L. The source of toxicity is profenos cypermethrin. Fantom C 315 EC, which is classified as moderately hazardous (FAO Class II), has the following characteristics: (i) an oral acute toxicity (rat, female) of LD < of 550 mg/kg, (ii) an acute dermal toxicity of LD\(_{50}\) >2000 mg/kg, (iii) an acute toxicity (fish) LC\(_{50}\) of about 0.03 mg/1, (iv) growth inhibition (algae) EC\(_{50}\) of about 4 mg/1, (v) toxicity to aquatic invertebrates of EG\(_{50}\) of about 0.03 mg/1. The source of toxicity is profenos lambda-cyhalothrin.

10. Application of Monceren GT to cotton seed to control soil and early season sucking insect pests in cotton

Partially released in March 2005 by the National Cotton Improvement Programme in collaboration with Farmers' Organization. An application of Monceren GT at the rate of 1.5 litres per 100 kg seed cotton is effective in controlling soil and early season sucking insect pests of cotton for a period of between 6-8 weeks after planting. Monceren GT, which has three active
ingredients: (i) imidacloprid (233 g/1), a systemic insecticide, (ii) thiram (107 g/1), a
dumping-off fungicide, and (iii) pencycuron (50 g/1), a rhizoctonia fungicide, that controls
many early season insect pests including: (i) aphids (Aphididae), (ii) whiteflies (Bemisa tabaci),
(iii) thrips (Thysanoptera), and (iv) leafhoppers (Cicadellidae); and dumping-oil diseases, such as
Rhizoctonia solani. Monceren GT is available as a liquid formulation that is red in colour with a
slight characteristic smell. It is miscible in water and is characterized by: (i) a pH of between
6.0-7.5, (ii) a density of 1.17 g/cm³ at 20 °C, and (iii) a viscosity of 300-500 mPa-s at 20 °C. It
has the following rat acute toxicities: (i) LD₅₀ oral of > 500 - <1000 mg/kg, (ii) LD₅₀ dermal of
>4000 mg/kg, and (iii) LD₅₀ inhalation of >2.5 mg/l. It is non-irritant to rabbit skin, but has a
sensitizing effect on guinea-pigs. This chemical product is a liquid formulation of the dust
Gaucho 70⁰ that was released some two years ago for use as a cotton seed dressing. The
advantage of the liquid formulation (Monceren GT) is that it is easier to apply and is less
expensive compared with the dust formulation (Gaucho 70⁰).

11. Application of Harness EC to control weeds in cotton
Released in March 2004 by the National Cotton Improvement Programme in collaboration with
Farmers’ Organization. An application of Harness EC at the rate of 1.0 litres/ha (range 0.75-1.5
litres/ha) for soils with a clay content of 0-10%, or 2.0 litres/ha (range 1.0-3.0 litres/ha) for soils
with a clay content of 11-30%, is effective in controlling annual grasses and certain broadleaf
weeds in cotton for a period of up to 2 weeks after application. He further explained that
farmers can prepare a formulation that will supply 1.0 or 2.0 litre/ha by adding 15 ml or 30 ml of
Harness EC to 15 litres of water, respectively. Harness EC, whose active ingredient is
acetochlor 900 g/litre, controls: (i) up to eight common grasses that include crab linger grass
(Digitaria sanguinais), goose grass (Elusine indica), herringbone grass (Urochloa panicoides) and
buffalo grass (Panicum spp), and (ii) up to thirteen broad leaf weeds, including pigweed
(Amaranthus spp), wandering Jew (Commelina benghalensis), early germinating Thom apple
(Datura spp), wild gooseberry (Physalis angieta) and khaki weed (Tangetes minuta). For effective
and optimal weed control, farmers should apply Harness EC within three days after cultivation
that is followed by 10-15 mm of rain. This is because the efficacy of Harness EC is reduced if
the field is cultivated after the application of the chemical product. Harness EC, which is an
emulsifiable concentrate (EC) pre-emergence herbicide, has the following rat toxicological
data: (i) acute oral (LD₅₀ mg/kg) of 2,953 mg/kg, (ii) acute dermal (L.Dm mg/kg) of 3,667
mg/kg, and (iii) inhalation (LD₅₀ mg/l/hour) of >3.85 mg/l/hour. However, Harness EC causes
skin and eye irritation on rabbits, and may cause sensitisation in some individual human beings.
Nonetheless, Harness EC is rated mild (Class II) by the World Health Organization (WHO),
although it is: (i) slightly toxic to bees, (ii) moderately toxic to aquatic organisms, and (iii)
slightly toxic to birds. It has no potential risk to microorganisms.

3.4 Horticultural Crops Production Technologies
Many horticultural crop production technologies have so far been developed. However, only
those on tomato, cabbage, paprika and coffee have been officially released for production by
farmers.

3.4.1 Tomato
The recommended tomato production technologies have mostly addressed the problem of red
spider mite under smallholder farm conditions, and the use of plastic shelter mulch to control
late blight disease.

1. Intercropping tomato with onion to reduce red spider mite infestation on tomato Released in
August 2001 by the National Plant Protection Improvement Programme. Intercropping tomato
with onion is effective in reducing mite infestation in tomato resulting in higher yields when
compared with tomato grown in pure stand. Mites are visible as red or reddish-brown dots on
the underside of the leaf. Their generation period varies between eight and 21 days depending on temperature. In winter, red spider mites become dormant and hide under plant debris. Eggs are white to amber in colour and visible only under magnification. Larvae have three pairs of legs, pinkish in colour and develop into eight-legged nymphs. Adults are usually bright red or reddish brown. Infested plants attain a yellow mottled appearance (which has locally been referred to as "stonewashed appearance"), whereas severely infested leaves appear completely burnt-out resulting into the whole plant dying. The fruits from severely infested plants fail to ripen, and are characterized by yellow spots. Mites are often dispersed by the following means: wind, farm equipment, containers, produce, clothing, footwear, insects and seedlings. To reduce mite infestation, use all field sanitation practices that include: (i) uprooting and burning infested plants and crop residues after harvest, (ii) burning all left over seedlings after transplanting, and (iii) intercropping tomato with onion. Onion has a repellency effect, or masking effect, on the mites. This depends on the time of onion planting and the planting pattern of the tomato and the onion. Onion should be transplanted four weeks before the transplanting of tomato. This ensures that the onions are fully established, and start emitting enough pungent smell before the onion is planted. Transplant both onion and tomato in rows at their recommended plant spacing. Plant at least three to four seedlings of onion in between tomato planting stations.

2. Application of tobacco, ash and soap concoction to control red spider mite in tomato
Partially released in August 2001 by the National Plant Protection Improvement Programme. An application of a concoction of tobacco, soap and ash is effective in controlling red spider mite on tomato. The concoction consists of tobacco + soap + ash. (handful of dark fire cured tobacco, a quarter tablet of soap (30 g) and a handful of ordinary ash). This is mixed and boiled in five litres of water, and cooled overnight. This concoction is sprayed to tomato every two weeks based on fortnightly scouts.

3. Application of plastic shelter mulch to control late blight disease in tomato
Released in August 2002 by the Lobi Horticultural Extension Project of the Lilongwe Agricultural Development Division (LADD). An application of plastic shelter mulch, in combination with dithane, is effective in controlling late blight (Phytophthora infestans) disease in tomato (Lycopersicon esculentum). Kite blight (LB) disease is most severe under cool temperatures and prolonged leaf wetness, as those experienced at Lobi in Dedza. To control this disease, farmers are currently using dithane. However, LB infestations in the rainy season are so severe than fanners frequently apply large quantities of this chemical, resulting in increased production costs and reduced profits. An alternative solution to chemical sprays is the growing of tomatoes under plastic shelter mulch, combined with weekly sprays of Dithane M 45 at the rate of 2 g/litre, which is more effective and cheaper than spraying dithane alone.

3.4.2 Cabbage
The recommended cabbage production technologies have mainly addressed the problem of controlling clubroot disease and the use of plastic shelter mulch to control late blight disease. This work has been conducted by a team of DARS scientists working in partnership with farmers and field extension stall under the auspices of the Malawi- German Plant Protection Project (MGPPP). The use of plastic shelter mulch is an initiative of field extension staff in Lilongwe ADD under the Lobi Horticultural Project funded by the Japanese Overseas Cooperation Agency (JICA).

1. Application of agricultural lime to control clubroot disease in cabbage
Released in August 2002 by the National Plant Protection Improvement Programme. Air application of agricultural lime at the rate of 7,500 kg lime/ha is effective in controlling clubroot disease in cabbage. The changes that occur in the soil following the application of lime,
including soil pH, were monitored to determine the incidence and severity of clubroot disease and cabbage yields. The application of 7, 5000 kg lime/ha is effective in reducing disease incidence and severity, and increasing soil pH.

2. Application of solarization to control clubroot disease in cabbage
Solarization is the technology that uses a plastic sheet mulch to control the incidence and severity of clubroot disease in cabbage, which finally leads to increased good quality cabbage yields. This is a hydrothermal process that occurs in a moist soil that is covered by a transparent plastic film and exposed to sunlight during the warm months of the year. During solarization, high temperatures are developed under the plastic mulch that is lethal to many plant pathogens, including *Plasmodiophora brassicae*, the pathogen that causes clubroot disease. The temperatures are raised to more than 30 °C in the upper soil layers (0-30 cm), which are more than sufficient to kill the *Plasmodiaphora brassicae* pathogen, hence increased cabbage yields leading to economic benefits to the farmer.

3. Application of Flusulfamide to control clubroot disease in cabbage
Released in August 2002 by the National Plant Protection Improvement Programme. An application of flusulfamide 5% SC at the rate of 6 l/ha is effective in controlling clubroot disease in cabbage. This is economical and effective if 6 l/la of flusulfamidc is applied before planting.

3.4.3 Paprika
There is only one recommended paprika production technology. This specifies the optimum plant spacing of 15 cm for paprika seedlings to optimize yields and quality.

1. Planting Paprika (*Capsicum annum* L) at a spacing of 15 cm between plants to increase yields and quality
Partially released in November 2005 by the National Paprika Improvement Programme. A plant spacing of 15 cm between Paprika (*Capsicum annum* L) plants is sufficient to optimise paprika yields. At 15 cm spacing, canopy spread, plant height and number of pods per plant are increased significantly compared with wider plant spacing. Paprika, which originates in from Central and South America, and was introduced into Malawi in 1994, is an important cash crop that is used in the food colouring, cosmetic and pharmaceutical industries. However, further work is required to evaluate other plant spacing that are smaller than 15 cm, and the effect of different ridge spacing, so as to come up with a complete production package for paprika. The main attribute of paprika is its high market potential and for crop diversifying away from tobacco.

3.4.4 Banana
There is only one banana production technology that has so far been recommended for use by farmers. This technology is the application of the split corm technique to accelerate the production of banana and plantain planting materials.

1. Application of the split corm technique to enhance the production of banana planting materials
Released in August 2003 by the National Banana Improvement Programme. The split corm technique is an effective, efficient and rapid technique for multiplying banana-planting materials. The split corm technique is recommended as an alternative method to tissue culture and the use of sword suckers. The split corm technique involves the following steps: (i) uprooting the corms to be used, and discarding damaged or diseased ones, (ii) cutting the corms in sizes of approximately 50 g with or without buds (eyes), (iii) treating the corms with a 1% (10 g in 1 litre of water) of benomyl (Benlate) solution, (iv) air-drying the corms in the shade for 24 hours, (v) planting the treated corms in river sand that is mixed with manure (in the ratio of 1:1)
at a spacing of 15 x 15 cm on nursery beds, and (vi) transplanting the germinated corms in polyethylene pots. This is a clean and rapid method for multiplying banana-planting materials that greatly increases the number of planting materials and reduces the planting of diseased seedlings.

### 3.4.5 Coffee

The coffee production technologies developed have focused on the control of the notorious coffee stem borer (*Monochamus leuconotus* (Pascoe) (Coleoptera: Ccrambycidae) that adversely affects coffee under smallholder farm conditions.

1. **Application of Reagent® 200SC (Fipronil) and Confidor® 200SL (Imidacloprid) to control the coffee stem borer (CSB)**

   Partially released in August 2003 by the National Coffee Improvement Programme. An application of Reagent® 200SC (Fipronil) at the rate of 500 ml in 100 litres of water or Confidor® 200 SL (Imidacloprid) without diluting, are effective in controlling the coffee stem borer (CSB). It is recommended to apply a single dose of any of the chemical products in a year, thereby cutting down on costs. However, this technology was only partially released because it is in high demand by coffee farmers and that recommended chemicals, Aldrin and Dieldrin, are now proscribed and no longer available. Further, more data are required on LD₅₀ values, toxicity levels, safety precautions, etc., which need to be fully specified, and carrying out more on-station and on-farm demonstrations.

2. **Application of Fipronil to control the coffee stem borer (CSB)**

   Fully released in November 2005 by the National Coffee Improvement Programme. An application of Fipronil at the rate of 0.5 litre per ha is effective in controlling the coffee stem borer (*Monochainus leuconotus* (Pascoe) (Coleoptera: Cerambycidae) that attack coffee bushes. Fipronil, also known as Reagent® 200SC, Adonis or Termidor, is a soluble concentrate (SC) whose active ingredient is phenyl pyrazole and its mode of action is contact and stomach action. It degrades easily in the soil and in water, and its toxicity has been classified "Class II" by the World Health Organization (WHO). It has an LD₅₀ value of 97 mg/kg and a withholding period of more than 200 days, and very toxic to aquatic life. This chemical product should be applied starting from October every year to coincide with the on-set of the rains when the coffee stem borer emerges and starts laying its eggs. Fipronil is now fully released for use by farmers, provided they take into account all the precautionary and protective measures to avoid contaminating the environment.

### 3.5 Livestock Production Technologies

This section provides information on two livestock production technologies that have been developed and recommended during 2005. These include a feed supplement to enhance dairy cow milk production and methods of rearing hyline chickens.

#### 3.5.1 Dairy cattle

Only one cattle production technology has been release and recommended for use by farmers. This technology is a feed supplement that increases milk production.

1. **Use of the Chitedze liquid feed supplement to increase milk production in dairy cows**

   Released in August 2005 by the National Livestock Improvement Programme. An application of the "Chitedze liquid feed", as a supplementary feed to dairy animals, is effective at enhancing milk production: Supplementing the feed of dairy cows with the "Chitedze liquid feed" increases milk yield by more than 30%. This feed consists of 70% molasses, 10.8% urea, 18% water, 0.1% vitamin and 1.1% trace minerals. The mixture is a result of dissolving urea in water and then adding dissolved vitamins (A, D and E), trace minerals and the molasses. The liquid
feed should be fed at 5% of the total ration (i.e., 90% dry matter basis) or 0.02% of the animal body weight, with a maximum intake of 1.5 kg per day per 600 kg animal, and the animals should not be fed more than 1.5 kg/day. This liquid feed should not be given to young animals that are less than six months old or animals that have not been fed any other type of food (i.e., hungry animals). Further, do not over-feed the animals so as to avoid ammonia poisoning. In the event that animals exhibit symptoms of ammonia toxicity (foaming on the mouth, breathing difficulties, and prostration), remove the liquid feed and drench the animal with one litre of vinegar immediately. If this treatment is done on time, the animal should recover quickly.

3.5.2 Poultry
One poultry production has been officially released and recommended for use by smallholder farming communities.

2. Raising Hyline chickens under semi-scavenging conditions
Released in November 2005 by the National Livestock Improvement Programme. Hyline chickens, which have been bred to lay eggs under controlled rearing conditions, are equally superior in their performance under local farmers semi-scavenging conditions when compared in with the Black Austrolop (BA) and Local chickens (LC) in terms of: (i) average number of eggs per bird (223 vs 85 and 40 for Hyline, BA and LC, respectively), and (ii) cumulative mortality rate (%) (4 vs 50 and 3 for Hyline, BA and LC, respectively). After 18 weeks, the Hyline breeds weighed some 1.6 kg compared with 2.8 for BA and 1.5 LC, (ii) reached 50% egg production at 150 days compared with 156 for BA and 145 for LC, and (iii) gained 2.25 kg after 72 weeks compared with 2.86 and 1.74 kg for BA and LC, respectively. The main attribute of this technology is the production of a large number of eggs from Hyline chickens under semi-scavenging conditions. However, farmers should supplement their chicken's diet with the Chitedze Layers Mash (60% maize, 25.3% roasted soybean, 3% fish meal, #% bone meal, 0.2% premix, 0.5% salt, 6% limestone, and 2% Leucaenaleucocephala), and control all the common diseases, such as Newcastle disease, Gumboro and fowl pox, to ensure superior performance.
Chapter 4: Agricultural Processing and Utilization Technologies

4.1 Introduction
One of the major challenges in Malawi is to add value to developed and recommended agricultural technologies. Adding value is more important for crops that are perishable and have a short shelf life, such as mangoes, tomatoes and oranges. It is against this background that the Farm Machinery Commodity Team at Chitedze has developed two agricultural processing and utilization technologies.

4.2 Agricultural Processing Technology
Two fruit juice extractors: (i) Mfinyazipatso Owerama, and (ii) Mfinyazipatso Oyimilira have been developed to extract fruit juices, jams and purees from the pulp of vegetables (tomato) and indigenous and exotic fruits that are grown locally in Malawi.

1. Application of the vertical and horizontal hand-operated fruit juice extractors
Released in August 2005 by the National Farm Machinery Improvement Programme. An application of Mfinyazipatso Owerama (Horizontal) and Mfinyazipatso Oyimilira (Vertical) hand-operated fruit juice extractors is effective in extracting fruit juices from the pulps of indigenous and exotic fruits. Both machines have plastic bottles so that they do not react with the juice concentrate to maintain juice quality, and they use horizontal and vertical screw press principles for ease of hand operation while standing or seating. Specifically, Mfinyazipatso Owerama contains a tapered horizontal screw outside of which is a barrel that squeezes the pulp of fruits using horizontal and side compressive forces. The machine is designed in such a way that one end is bigger (16 cm in diameter) than the other end (5 cm in diameter) giving a compression ratio of 3:1. This machine has been designed to be mounted on a wooden pole stand inclined at an angle of 30°. This angle allows for effective downward flow of the pulp as the tapered horizontal screw is rotated by hand. This machine has a pulp extraction rate of 11-15 l/hr, an extraction efficiency of 75-85%, power requirement of 50-60 W, rest period of 240-300 min/hr, an operating speed of 7-20 rpm, and a stone breakage of zero. On the other hand, Mfinyazipatso Oyimilira, which is also mounted on a wooden pole, has similar design features as the Mfinyazipatso Owerama, with the main difference that it is positioned vertically upwards. It has two plastic barrel gears that are meshed at 90°. The vertical gear, which is located at the side of the barrel, is rotated by hand and transmits power to the top horizontal barrel. This design, fruits fall freely due to the force of gravity during pulp extraction, hence less effort is expended on the handle. This design also allows for more vertical and sideways compressive forces. This machine has a pulp extraction rate of 50-60 l/hr, an extraction efficiency of 78-86%, power requirement of 40-50 W, rest period of 300-390 min/hr, an operating speed of 7-20 rpm, and a stone breakage of zero.
4.3 Agricultural Utilization Technologies

After the development of the two fruit juice extractors, different recipes, and/or procedures for making ready-to-drink juices and ready-to-eat jams have also been developed and recommended for use by farmers.

2. Application of different procedures to make ready-to-drink fruit juices and jams Released in August 2005 by the National Farm Machinery Improvement Programme. Application of different procedures and recipes for making ready-to-drink fruit juices and jams of various indigenous and exotic fruits have been developed and are now ready for use by the farming communities. These recipes have been developed in collaboration with the Malawi Bureau of Standards (MBS) and farming communities. The range of procedures has been developed for making: (i) juices and jams from mangoes, *masesu*, guava and pawpaw; (ii) juices and spread from *mulambe*, (iii) juices from pineapples, lemon, tangerine and tomato, and (iv) juice, sauce, puree and jams from tomato. The main steps involve: cleaning and peeling, mixing the pulp with water, mixing, stirring, sieving, adding sugar, heating, adding a preservative, sterilizing the bottles and filling the bottles with ready-to-drink juices. The main ingredients of ready-to-drink juices are: fruit pulp, water, sugar, sodium benzoate (a preservative) and citric acid. The procedure for making fruit spread includes: evaporating the water from the sieved remains of the fruit juice, adding preservatives, heating, sterilizing the packing bottles and filling the bottles. The main ingredients of fruit spread are the fruit pulp, sugar, citric acid and sodium benzoate. The procedures for making jams are essentially the same as those described for making fruit juices. The ingredients are also the same, only that in some cases salt too may be added. The procedures or recipes for making ready-to-drink fruit juices, spreads and jams have been partially released as they are awaiting final certification from MBS in compliance with the Technology Protection Act.

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APPENDICES

Appendix 1: Agro-ecological zones of Malawi

MALAWI

Lower Shire Valley: < 200 m elevation
Lake shore, Middle & Upper Shire: 200 - 760 m
Mid-elevation Upland
Plateau: 760 -1300 m
Highlands: >1300 m

produced by GIS Unit - Chitedze, Malawi (June, 2001)
Appendix 2: Mean annual rainfall distribution

MALAWI

Produced by GIS Unit, Chitedze - Malawi June 2001

600 - 800 mm
800 - 1200 mm
1200 - 1600 mm
1600 - 2000 mm
>2000 mm

Agricultural technologies released by the Ministry of Agriculture and Food Security: 2000-2005

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Appendix 3: Mean annual temperature distribution
Appendix 4: Soils Map of Malawi