Report of a Workshop on Integrating Pastures, Fodders, and Cereal Crops as Refugia for Stem Borers in the Farming Systems of the Humid Coastal Kenya, 26-29 July 2004

M. Mulaa, S. Mugo, B. Muli, and D. Poland
(Editors)

IRMA Project Document No. 17

ndation
ustainable
culture

KARI

CIMMYT

Report of a Workshop on Integ
Fodders, and Cereal Crops as Refugia for Stem Borers in the Farming Systems of the Humid Coastal Kenya, 26-29 July 2004

M. Mulaa, S. Mugo, B. Muli, and D. Poland
(Editors)

IRMA Project Document No. 17

Participants of the workshop on integrating pastures, fodders and cereal crops as refugia for stem borers in the farming systems of the humid coastal Kenya, July 26-29, 2004, KARI, Mtwapa.

The Kenya Agricultural Research Institute (KARI) (http://www.kari.org/) was established in 1979 with the express mission of increasing sustainable agricultural production by generating appropriate technologies through research, and disseminating these to the farming community. Inherent to this mission is the protection, conservation, and improvement of the basic resources, both natural and human. Such resources are critical for Kenya's agricultural development and expansion of the nation's scientific and technological capacity. KARI has an extensive history of productive collaborators with national and international institutes and universities, as well as with the private sector.

The Syngenta Foundation for Sustainable Agriculture provides major funding for the project. The Foundation is dedicated to fostering sustainable development in poor countries of the South through its support of programs and projects in the areas of sustainable agriculture, health, and social development. It is also an active player in development policy debate through its preparation and dissemination of research analysis. Further information about the Foundation may be found at its web site (http://www.syngentafoundation.com/).

CIMMYT® (http://www.cimmyt.org/) is an internationally funded, not-for-profit organization that conducts research and training related to maize and wheat throughout the developing world. Drawing on strong science and effective partnerships, CIMMYT works to create, share, and use knowledge and technology to increase food security, improve the productivity and profitability of farming systems, and sustain natural resources. Financial support for CIMMYT's work comes from many sources, including the members of the Consultative Group on International Agricultural Research (CGIAR) (http://www.cgiar.org/), national governments, foundations, development banks, and other public and private agencies.

The Insect Resistant Maize for Africa (IRMA) Project was launched is a collaborative effort between CIMMYT and KARI. Its primary goal is to increase maize production and food security for African farmers through the development and deployment of maize that offers resistance to destructive insects, especially stem borers. To achieve this goal, project scientists will identify conventional and novel sources of resistance to stem borers and incorporate them into maize varieties that are both well adapted to Kenya's various agro-ecological zones and well-accepted by its farmers and consumers. Varieties and technologies that are appropriate for other African nations may be extended to them for their use.

Correct citation: Mulaa, M., S. Mugo, B. Muli, and D. Poland (Editors). 2005. *Report of a Workshop on Integrating Pastures, Fodders and Cereal Crops as Refugia for Stem Borers in the Farming Systems of the Humid Coastal Kenya, 26-29 July 2004*: IRMA Project Document No. 17. Nairobi, Kenya and Mexico D.F.: KARI and CIMMYT.

AGROVOC Descriptors: *Zea mays*; Maize; Pests of plants; Plant production; Food production; Cereals; Stem eating pests; Pest insects; Forage; Damage; Losses; Farming systems; Cropping systems; Resistance to injurious factors; Pest resistance; Kenya; Africa

Dewey Decimal Classification: 633.156

ISBN: 970-648-133-8

Additional Keywords: KARI; CIMMYT
Design and Layout: Marcelo Ortiz Sánchez

Table of Contents

Abbreviations vi
Executive Summary vii

1. Opening Session 1
- 1.1 Welcome, introductions and remarks by Centre Director Mtwapa 1
- 1.2 Remarks by Coordinator IRMA project 1
- 1.3 Official opening speech 2
- 1.4 Objectives of the workshop 3
- 1.5 Overview of the KARI/CIMMYT IRMA project 3

2. Sharing Experiences on Research and Extension Work on Fodders and Pastures in the Coast Province 6
- 2.1 Importance of refugia and ongoing and future research work 6
- 2.2 Farming systems of Coast Province 11

3. Reports from Coast Province Districts on Major Fodders/Forages Grown by Farmers 14
- 3.1 Kwale District 14
- 3.2 Mombasa District 16
- 3.3 Lamu District 18
- 3.4 Kilifi District 20
- 3.5 Malindi District 23
- 3.6 Tana River District 24

4. Natural Pastures, Fodders and Grasses and Their Distribution in Coast Province 27

5. Pasture and Fodder Utilization in Coastal Kenya 29

6. Review of Pasture/Fodder Research Work in the Coastal Lowlands of Kenya 32

7. Farmers Comments on Their Experiences with Growing and Utilization of Pastures and Fodders 35
- 7.1 Omari R. Mwamarifa Farmer Kwale District 35
- 7.2 Mohammed A. Bandari, Farmer Kwale District 35
- 7.3 Ahmed Mohammed, Farmer, Lamu District 35
- 7.4 Changawa Charo, farmer and official Mkenge Youth Group, Malindi District 36
- 7.5 Serah Luwali, Farmer and official, Bidii Self Help Group, Malindi District 36
- 7.6 Emmanuel Yaa, Farmer and official Tumaini FFS, Kilifi District 37

8. Field Visit to Livestock Farmers Near KARI Mtwapa (Lessons Learnt) 38

9. Practical Experiences with Refugia Species 39
- 9.1 Group exercise on ranking of refugia 39
- 9.2 Group presentations in plenary session 40

10. Harmonizing Project, Researcher, Extension and Farmer Performance Indicators 45

11. Developing Participatory Monitoring and Evaluation Frameworks 47

12. General Discussions (Question/Answer Session) 50

13. Closing Session 52

References 54

Appendix A: Workshop program 56
Appendix B: Workshop budget 58
Appendix C: Expected participants 59
Appendix D: Form for paying subsistence allowance 60
Appendix E: Invitation letter to workshop 61
Appendix F: Materials used during the workshop 63
Appendix G: List of names and addresses of workshop participants 64

◄ List of Tables

Table 1. Summary means for damage and plant performance parameters 8
Table 2. Relative insect production potential from different crop groups 8
Table 3. Average weight of four species of stem borer reared on four groups of hosts 9
Table 4. Life cycle and reproductive potential for *B. fusca* and *S. calamistis* under laboratory conditions 9
Table 5. Vegetation survey results for Mombasa/Kilifi refugia 9
Table 6. Cropping activity calendar for Coastal lowlands of Kenya 11
Table 7. Food crop acreage and production in Kwale District 12
Table 8. Food crop acreage and production in Mombasa District 12
Table 9. Food crop acreage and production in Kilifi District 13
Table 10. Food crop acreage and production in Malindi District 13
Table 11. Food crop acreage and production in Tana River District 13
Table 12. Food crop acreage and production in Lamu District 13
Table 13. Improved maize acreage in the Coast Province of Kenya 13
Table 14. Livestock population in Mombasa District 16
Table 15. Land use and potential in Mombasa District 16
Table 16. Major fodder/forages grown in Mombasa District 17
Table 17. Livestock population estimates in Lamu District 19
Table 18. Types of fodder/forages and pastures in Lamu District 19
Table 19. Summary of livestock production in Kilifi District 20
Table 20. Maize and sorghum production (long rains 2004) in Kilifi District 20
Table 21. Groups of farmer field schools in Kilifi District 21
Table 22. Summary of fodder production situation in Kilifi District 22
Table 23. Main species of grasses found in Kilifi District 22
Table 24. Malindi District background information 23
Table 25. Pastures grasses in Malindi District (production, management and utilization) 23
Table 26. Forage legumes and root crops in Malindi District (production, management and utilization) 23
Table 27. Agroecological zone (AEZ) of Tana River District 24
Table 28. Livestock production in Tana River District 25
Table 29. Maize production in Tana River District 25
Table 30. Napier grass productivity, climatic and forage parameters in Coast Province 27
Table 31. Natural and arable land in seven districts of Coast Province 27
Table 32. Fodder crops area in the Coastal districts of Kenya 28
Table 33. Percentage of grass species dominance in the Coast Province 29
Table 34. Common, botanical and local names for pastures and fodders used in Coast Province 30
Table 35. Chemical composition (%) of the most abundant fodders and pastures at the Coast 30
Table 36. Feed chemical composition (%) and milk yield on use of 3 different legumes 30
Table 37. Total dry matter intake (TDMI) and average daily gains (ADG) in goats fed on different diets 31
Table 38. Chemical composition (%) of feeds offered to goats 31
Table 39. Fodder Dry Matter (DM) yield based on four harvests during second cropping year 33
Table 40. Experiences of Mkenge farmer group on pasture and fodder production and utilization 36
Table 41. Experience of Bidii self help group on pasture and fodder production and utilization 36
Table 42. Group I data collected by farmers 40
Table 43. Group 2 data collected by extension staff 41
Table 44. Group 3 data collected by researchers 42
Table 45. Ranking of pastures and refugia by farmers, extensionists, and researchers and criteria used 43
Table 46. Summary of selected species and selection criteria for pastures and refugia 44

List of Figures

Figure 1. Transgenic and non-transgenic maize in the Biosafety Level II Greenhouse Complex 4
Figure 2. Opening of the BGHC by His Excellency Hon. Mwai Kibaki, the President of The Republic of Kenya on 23 June 2004 4
Figure 3a. Maps of refugia distribution in Kenya - "short rains" based on farmer surveys 10
Figure 3b. Maps of refugia distribution in Kenya - "long rains" based on farmer surveys 10
Figure 4. Map of Coast Province showing district boundaries 11
Figure 5. Agroecological zones of Kwale District 15
Figure 6. Agroecological zones of Lamu District 18
Figure 7. Map of Kilifi District 21
Figure 8. Agroecological zones of Kilifi District 21
Figure 9. Agroecological zones of Tana River District 24
Figure 10. Livestock on Mr. Katana Masha's farm, Bomani location, Kilifi District 38
Figure 11. Farmers examining tunneling and counting stem borer larvae and pupae 39
Figure 12. Extension staff examining tunneling and counting stem borer larvae and pupae 39
Figure 13. Farmers group data analysis and discussions 39
Figure 14. Farmer representative presenting results during plenary session 39

Abbreviations

ADG	Average daily gains
AEZ	Agro-ecological zone
ALP	African Livelihoods Program (Of CIMMYT)
ASL	Arid and semi-arid lands
ATIRI	Agricultural Technology and Information Response Initiative
BGHC	Biosafety greenhouse complex
BISP	Bura Irrigation Settlement Project
Bt	*Bacillus thuringiensis*
CBS	Central Bureau of Statistics (of GoK)
CD	Center Director (of KARI)
CIMMYT	International Maize and Wheat Improvement Center
CL	Coastal lowlands
CP	Crude protein
DLO	District Livestock Officer
DLPO	District livestock production officer
DM	Dry matter
EE	Ether extract
FFS	Farmer field school
GIS	Geographical information system
GoK	Government of Kenya
ICIPE	International Center for Insect Physiology and Ecology
IDA	International Development Association
ILRI	International Livestock Research Institute
IRM	Insect resistance management
IRMA	Insect Resistant Maize for Africa (KARI-CIMMYT Project)
KARI	Kenya Agricultural Research Institute
KES	Kenya shillings
M&E	Monitoring and Evaluation
MoA	Ministry of Agriculture
MoL/FD	Ministry of Livestock and Fisheries Development
NARL	National Agricultural Research Laboratories (of KARI)
NDDP	National Dairy Development Project
OPV	Open pollinated variety
PAPO	Provincial Animal Production Officer
PCO	Provincial Crops Officer
PDA	Provincial Director of Agriculture
PDLP	Provincial Director of Livestock Production
PEC	Provincial Extension Coordinator
PLO	Provincial Livestock Officer
RELO	Research – Extension Liaison Officer
SED	Standard error of the difference
TDMI	Total dry matter intake
USA	United States of America

Executive Summary

The Insect Resistant Maize for Africa (IRMA) project is a joint project between Kenya Agricultural Research Institute (KARI) and the International Maize and Wheat Improvement Center (CIMMYT) with financial support from the Syngenta Foundation for Sustainable Agriculture. The goal of IRMA project is to increase maize production and food security through the deployment of insect resistant maize germplasm developed using conventional and biotechnology technology, such as Bt maize, to reduce losses due to stem borers. In Kenya,stem borers inflict maize yield losses estimated to be on average 13.5% valued at KES 5.6 billion (US$ 72 million) annually. Surveys conducted between 1995 and 2002 indicate that Kenyan farmers use several insecticides (mostly trichlorophon, fenitrothion, permethrin and Bulldockä), and/or local technical knowledge (e.g., ash, soil, chilies, plant products) for stem borer control, while some make no attempt to control stem borers. Using chemical control (Bulldock) on approximately 70,000 ha of maize grown in the Coast Province would cost about KES 22 million annually, when applied at the rate of 2.5 kg/ha (not including the cost of labor for application [PDA, Coast Province]).

Insect resistant plants, e.g., transgenic plants with insecticides derived from the common soil bacterium *Bacillus thuringiensis* (Bt), are becoming increasingly important for pest management mainly because the insecticidal crystal proteins (also called d-endotoxins) from Bt are extremely toxic to certain pests, but cause no harm to humans, most beneficial insects, and other nontarget organisms. Other advantages of transgenic plants over pesticide use are that they offer labor-free insect protection throughout the plant growth cycle, from seedling to maturity, and the pesticide is confined to plants thus limiting soil and water pollution.

One concern about utilizing Bt maize technology is the possible development of resistance to the Bt toxins by the target stem borer species. However, the rate of evolution of resistance can be slowed or stopped through the use of appropriate resistance management strategies. To this end, the IRMA project is developing maize varieties that carry Bt and conventional resistance. In addition, resistance management strategies are being developed; the primary strategy being provision of a refuge consisting of host plants that do not produce the toxins (refugia) and can maintain populations of nonresistant borers that will breed with potentially resistant borers and limit the build-up of resistant insect populations. To be accepted by farmers, however, IRM strategies must conform to existing cropping systems, and the refugia crops must be economically viable and socially acceptable to farmers.

For the past three years, IRMA scientists have conducted field trials and lab bioassays to screen and identify suitable refugia crops. Their findings indicate that fodders and cereal crops such as sorghum, maize, Columbus grass, pearl millet, giant setaria and some napier grass varieties are suitable refugia, based on the researchers' criteria. The scientists have also conducted surveys in 15 major maize growing districts in Kenya to estimate and document the area covered by existing potential alternative hosts of major stem borer species that may be recommended as natural refugia. They have also mapped the potential refugia at a district level to identify regions where structured refugia may be necessary. To complement the researchers' efforts and increase the chances that the Bt maize and refugia concept will be accepted by the farmers, the IRMA scientists organized a workshop to get the farmers input, with the following objectives:

(1) Create awareness in Kenya about the development of insect resistant maize through conventional and Bt gene-based resistance.
(2) Sensitize researchers, extension officers, and farmers to the importance of refugia in the management of insect resistance.
(3) Share information about research, adoption, production, utilization, and distribution of pastures/fodders in the Kenyan coastal region.
(4) Share information from the ongoing KARI/CIMMYT IRMA project collaborative field and laboratory trials on refugia.
(5) Identify potential refugia species for stem borers and management strategies to be tested on-station and on-farm, derived from the experiences of researchers, extension officers, and farmers.
(6) Harmonize researchers, extension, and farmer performance and process indicators, and develop frameworks for participatory monitoring and evaluation.

The workshop title was "Integration of pastures, fodders and cereal crops as refugia for stem borers in the farming systems of the humid coastal Kenya." The basis of the theme is the importance of livestock in coastal Kenya. More than 90% of the farmers in the coastal region keep livestock, and pastures and fodders are the main source of livestock feeds. The most abundant pastures/fodders for cattle at the coast are natural pastures (a mixture of grasses and local legumes, including trees and shrubs), napier grass, star grass, panicum and comellina. Sorghum, maize, pearl millet and foxtail millet are also grown by only a few farmers, but their area could be increased by sensitizing the farmers to their usefulness and by introducing improved varieties.

Thirty-two participants (12 farmers, nine extensionists, and12 researchers) attended the workshop. The extension staff and farmers were representatives from the major districts of Coast Province. The workshop was very participatory. An exercise was conducted to rank refugia species in the IRMA experimental plots at KARI Mtwapa by the 3 groups of participants and their respective criteria (farmers, extensionists, and researchers). Not surprisingly, different rankings emerged. The farmers' five best refugia species in ranked order were the local maize variety Mdzihana, local sorghum Brown 2, Napier 16837, and Pioneer maize. The species preferred by researchers were local sorghum Deep Red 9, pearl millet, and Pioneer maize, while extension staff chose three local sorghum varieties (Red, White, and Brown), and Columbus grass. The criteria for ranking refugia was based on the crop being able to resist borer attack, availability of seed and usefulness as livestock feed and food. The researchers and extension staff used the level of damage by stem borers as the major criteria for selecting refugia. When the criteria produced by the three groups were combined, the common aggregate criteria were resistance to stem borers, alternative uses, and the ability to attract and support stem borers. The farmers also mentioned availability of seed as an important criterion that should not be ignored.

Other information presented during the workshop included previous and ongoing research on pastures/fodders; the farming systems of the Coast Province; major fodders/forages grown by farmers (their yields, nutritional value, and preferred varieties); and types of natural pastures/fodders and grasses (their distribution and percent of area covered). Participants shared their experiences in growing and utilizing the pastures and fodders. A ground-level perspective was provided through a visit to two livestock farmers near the KARI-Mtwapa Center. Similar workshops are planned for other maize growing areas including Embu, Kakamega, and Kitale.

In conclusion, it was reinforced that farmers use their own criteria for judging technologies, and that these vary in different areas. We documented the criteria used to choose forage plants and the preferred potential refugia species for the humid coastal region. These criteria may be used as indicators to measure success or failure of projects. In concert with farmers and extensionists, new areas of research areas were identified.

1. Opening Session

1.1 Welcome, introductions, and remarks by Dr. Rahab Muinga, Center Director, KARI-Mtwapa

Dr. Muinga welcomed the participants to KARI-Mtwapa Center noting that this was a good forum for interaction between livestock and food crops officers from research and extension, and farmers. She noted that food crops extension officers in attendance were few because they had their chance for sensitization during extension seminars that were carried out by the KARI/CIMMYT IRMA project in 2002.

The Center Director informed the farmers and extension providers that the KARI-Mtwapa Center is open for all, including farmers, to visit and inquire about research and that no one should not be put off by quarantine regulations. She said the time for extension providers to go to the farmers is long past, and that farmers should actively seek assistance from research and extension rather than waiting to be reached by the officers. KARI centers are meant to serve farmers in their efforts to overcome food famine and hunger. The centers have developed technologies for many crops including maize, coconut, and cassava. At KARI-Mtwapa Center, farmers can also learn different farming technologies to increase food production and diversify crop production.

It was Dr. Muinga's hope and advice to the participating farmers to come learn and team up with research and extension officers, and to go and teach other farmers. Researchers need feedback from farmers and extension, and she advised the group to hold dialogue and raise important issues that would lead to increased food production in the Coast Province.

1.2 Remarks by the Coordinator of the IRMA Project, Dr. Stephen Mugo, CIMMYT African Livelihoods Program

Dr. Mugo noted that current maize production levels of about 300 million tons per year in Africa will not meet projected demand that is estimated rise to 500 million tons per year in the next 20 years The need to increase maize production is even more critical in Kenya, which is very dependent on maize. The problems facing maize production cannot be tackled by a single institution or by over-reliance on traditional technologies. The IRMA project was developed as a partnership among institutions to develop and deploy insect resistant maize using conventional breeding and biotechnology. CIMMYT's partnership in the IRMA project will be further strengthened by the creation of the African Livelihoods Program (ALP), based in Nairobi.

This workshop will help us develop better insect resistance management (IRM) strategies for the coastal region, with its unique agroecology and maize production systems. Similar workshops will be held at KARI-Embu, KARI-Kitale and KARI-Kakamega, and the scientists who will organize these workshops were invited to participate in this one.

Dr. Mugo thanked the center director of KARI-Mtwapa for hosting the workshop, the Coast Province Provincial Director of Agriculture (PDA) for the opening and sending his staff, Dr. Mulaa and Mr. Muli for organizing the workshop, and farmers for leaving their important activities to come and make significant contributions to the workshop.

1.3 Official opening speech by Mr. Jacob Odondi, Provincial Director of Agriculture (PDA), Ministry of Agriculture, Coast Province. Read by Mr. S. Abdillahi, PLO, Coast Province

IRMA Coordinator—Dr. Stephen Mugo,
Center Director KARI-Mtwapa—Dr. Rahab Muinga,
Extension Officers, Research Officers, Farmers,
Ladies and Gentlemen.

It is a great pleasure for me this morning to be part of this important workshop, particularly at this time when any effort to alleviate poverty and hunger is very close to our hearts.

As you might be aware, agriculture is the backbone of our economy. This is manifested by the sector's contribution of 26% to the GDP directly and 27% indirectly, 60% of the export earnings, and 60% of the employment.

About 80% of the Kenyan population lives in rural areas with agriculture as the main source of their livelihood. Agricultural growth led to general economic growth in the 1960s and 1970s when agriculture was registering positive growth and the general economic growth was vibrant. Today, about 60% of the Kenyan population lives below the poverty level. Subsistence farmers and pastoralists account for 50% of the poverty stricken people. On a more general level, about 51% of the Kenyan population lack access to adequate food that may also be of poor nutritional value.

The poverty level in the Coast Province is currently at 62%, but rises to more than 80% in some areas. Maize is the staple food in Coast Province, as in the whole country. The national maize production in 2002 and 2003 was 26 million and 28 million bags, respectively, while the requirement is 31 million bags annually.

Coast Province is a food deficit region, producing only 20% of its food requirement. In 2003, the province produced only 500,000 bags against a requirement of 2.5 million bags of maize. Although other food crops like cassava and cowpeas also do well, the production levels are low, being an average of 90,000 tons for cassava and 60,000 tons for cowpea. The produce from these two crops cannot, therefore, balance the food deficit.

The major constraints to maize production in our region include erratic rains, late and poor land preparation, planting of low yielding and unimproved maize varieties, low soil fertility, and losses due to pests and diseases.

The major maize field pest is the stalk borer also known as the stem borer which causes losses of up to 30% annually. Traditionally, farmers use ash, chilies, neem powder, and other products to control stem borers, but most methods achieve little, if any, success. Chemical control has been effective, but the resource-poor farmers cannot afford the high costs of pesticides. Chemical control using Bulldock on approximately 70,000 ha of maize grown in the province annually would cost close to KES 22 million when applied at the rate of 2.5 kg/ha. This does not include the cost of labor for application. It is paramount that alternative ways of controlling this pest be developed and supported. This therefore forms a demand driven research agenda, and I wish to thank KARI and CIMMYT for the work already underway.

As we continue with this research work involving genetically modified maize with the Bt gene technology, we should also focus the current and future challenges facing it. In recent months, there has been a lot of talk through the media on the potential effects of genetic engineering. I am glad to learn that the necessary precautions have been put in place in order to ensure the safety of farmers and consumers during research, dissemination, commercialization, growing and consumption of the Bt maize products. I hope that these biosafety measures will not lead to stigmatization of the ultimate products of Bt maize technology. Liaising and working together with the biosafety regulatory institution, KEPHIS, is of utmost importance all along the research and development path.

I wish to commend the program leaders for the inbuilt feedback mechanism and above all for bringing stakeholders on board at each stage, through fora like this one. I wish to urge the farmers to take the opportunity to understand the objectives of the research and constructively contribute towards this research agenda since they are the ultimate users of the technology.

Ladies and gentlemen, I want to take this opportunity to wish you a fruitful discussion during the two days you will be here.

And now, may I declare this workshop officially opened.

Thank you.

1.4 Objectives of the workshop

Dr. Margaret Mulaa, Entomologist, KARI-Kitale

(1) Create awareness in Kenya about the development of insect resistant maize through conventional and Bt gene-based resistance.
(2) Sensitize researchers, extension officers, and farmers about the importance of refugia in the management of insect resistance.
(3) Share information about research, adoption, production, utilization, and distribution of pastures/ fodders in the Kenyan coastal region.
(4) Share information from the ongoing KARI/CIMMYT IRMA project collaborative field and laboratory trials on refugia.
(5) Identify potential refugia species for stem borers and management strategies to be tested on-station and on-farm, based on the experience of researchers, extension officers, and farmers.
(6) Harmonize researchers, extension, and farmer performance and process indicators, and develop participatory monitoring and evaluation frameworks.

1.5 Overview of the KARI/CIMMYT Insect Resistant Maize for Africa (IRMA) project goals, objectives, activities, achievements, and future

Dr. S. Mugo, Coordinator IRMA Project, and Scientist Maize Breeder, CIMMYT ALP Program

Introduction

Kenya is a net importer of maize due to low maize production and productivity. The major physical causes of low maize production are low soil fertility, drought stress, leaf diseases like maize streak virus and leaf blights, the parasitic weed *Striga*, and insect pests in the field and in storage. There are socioeconomic factors such as input supply and marketing. Among field pests, stem borers are the most important in range and damage as reported in surveys and from actual measurements (De Groote et al. 2002). On average, stem borers in Kenya causes 13.5% damage valued at KES 5.6 billion annually.

Stem borers, the larval stage of moths, are very destructive to maize plants. There are five major stem borer species in Kenya: [*Chilo partellus* Swinhoe (Spotted stem borers), *Chilo oricalcocilielus* Swinhoe (Coastal stem borers),*Busseola fusca* Fuller (African stem borers), *S. calamistis* Hampson (pink stem borers) and *Eldana saccharina* Walker (African sugarcane borer)]. Every maize growing region in Kenya is infested by one or more of these species.

Stem borer larvae feed on the leaf surface and in the whorl, thereby reducing the plant's photosynthetic leaf area. When feeding continues down the whorl, it may cause total loss by destroying the growing point and leading to a condition known as "dead heart." The larvae will later burrow into the plant stalk, disrupting the flow of water and nutrients. Plant lodging may results from damaged stalks. Second generation infestation can occur with the larvae feeding on the grain. Damage to the grain often increases ear rots and aflatoxins may develop. Taken together, these factors lead to reduced grain yield in the affected crops.

There are several methods to control stem borers that vary by cost, availability, and effectiveness. These are cultural, chemical, biological using predators or parasites, and host plant resistance derived either through conventional or biotechnology methods. Host plant resistance provided through the seed is the method farmers find easiest to adopt.

IRMA project and Bt maize technology

CIMMYT and KARI planned and proposed the Insect Resistant Maize for Africa project to develop and deploy stem borer resistant maize, initially for Kenya, but with the intent that the project would share its experiences and products with other interested African countries. To provide a range of options to farmers, the project proposed using conventional breeding methods that would guarantee that farmers received a product in the short term and not be disillusioned, while genetic engineering using the *Bacillus thuringiensis* bacterium (Bt) would provide effective stem borer resistant maize for the longer term, with some of the added time dedicated to fulfilling the regulatory requirements that accompany transgenic technology.

The use of the genetically modified (GM) maize came with a host of additional considerations. The IRMA project chose to use marker-free, publicly-derived Bt maize events. Further, we had to generate baseline data on insect ecologies, including effects on nontarget arthropods, as well as develop feasible insect resistant management strategies. It was also important to study the maize farming systems and conduct impact assessments in the target growing conditions. Communications and education were to be emphasized to ensure that stakeholders understand the technology and contribute to its development. This workshop is intended to provide opportunities for the participants and those they represent to contribute towards the development of the feasible insect resistant management strategies among resource poor farmers in Kenya.

Using genetic engineering tools, modified novel genes from the soil-dwelling bacterium Bt were introduced into maize to control lepidopteran stem borers (National Academy of Sciences, 2000). The genes encode delta-endotoxin proteins. On ingestion by the susceptible stem borer, the proteins are activated by the conducive environment in insect guts to release active proteins that bind to the bush border membrane vesicles of the peritrophic membrane resulting in pore formation and hence larval mortality (Gill et al. 1992). The Bt toxins are active against lepidopteran pests but nontoxic to humans and livestock. Bt maize technology has been used in several countries including the USA, Canada, Argentina, South Africa, and Spain. Production has been increasing steadily since 1996, with Bt maize as the second most dominant transgenic crop in 2002, occupying 7.7 million hectares, equivalent to 13% of global transgenic area (James 2003).

The Bt technology is being pursued for a number of reasons. First conventional insect resistance is a quantitative or polygenic trait, i.e., the trait is controlled by a large number of genes, each with very little effect, and this makes it difficult to handle and less efficient to transfer. Bt resistance on the other hand is controlled by one or two genes that are easier to handle and more efficient to transfer. Secondly, using Bt technology would reduce the heavy reliance on chemical pesticides, which pose their own set of environmental and health risks. Finally, Bt technology can be readily combined with other stem borer control methods and can fit well into an integrated pest management strategy.

Figure 1. Transgenic and nontransgenic maize in the Biosafety Level II Greenhouse Complex.

Figure 2. Opening of the BGHC by His Excellency Hon. Mwai Kibaki, the President of The Republic of Kenya on 23 June 2004.

Achievements of the IRMA project

1. Conventional insect resistant maize germplasm has been developed and the first set of six OPVs was entered into the maize national performance trials in 2004. We look forward to releasing those and entering more especially hybrids.
2. Transgenic (Bt) maize plants with clean events (carrying only the gene of interest and not carrying selectable maker genes) were developed, and tested against Kenyan stem borers. The effective toxins and their Bt gene events were identified. The seeds of the preferred events were imported into Kenya and evaluation, seed increase, and conversion of adapted germplasm to Bt has been initiated.
4. Studies on nontarget organisms have been carried out and reference collection assembled, and these will be used as baseline data during monitoring phase of the project.
5. Field and laboratory testing of alternative hosts of stem borers have been conducted to assess their suitability as refugia.
6. Participatory rural appraisals were conducted in six maize growing zones with farmers throughout the country to document their practices, assess their needs, and determine their production constraints.
7. Facilities have been developed including a Level-2 Biosafety Greenhouse Complex that was inaugurated by his Excellency the President of Kenya, Hon. Mwai Kibaki in June 2004. Other facilities include a Level-2 Biosafety Laboratory at KARI- NARL, and an open quarantine site at Kiboko, among others.
8. Extensive training of staff from KARI and other government agencies has been done, including genetic engineering and management of biosafety facilities.

Concluding remarks

1. The IRMA project is a model of how major scientific and development projects can be successfully conducted through innovative partnerships, and effective institutional and disciplinary collaborations.
2. Insect resistant maize germplasm has been developed through conventional breeding, while Bt events and toxins effective against Kenyan stem borers have been identified.
3. A holistic approach to address the potential impacts on the environment and on the farming systems by insect resistant maize in Kenya was followed and baseline information has been generated against which monitoring will be done.
4. Stakeholders have been kept informed of the progress in the project and engaged through regular meetings, training, development of facilities, and through information dissemination

2. Sharing Experiences on Research and Extension Work on Fodders and Pastures in the Coast Province

2.1 Importance of refugia and ongoing and future research

M. Mulaa, Entomologist, KARI Kitale

Introduction

Maize is an important food and cash crop in Kenya. The area under maize in Kenya is approximately 1.5 million hectares with an annual production of 2.3 million tons. The average farmer's yield in most parts of the country is 1.1 to 1.3 t/ha, but higher in Trans-Nzoia District (2.8–5.6 t/ha). From participatory rural appraisals conducted in most parts of the country, stem borers were ranked among the major constraints to maize production (Khan et al. 1997; Mulaa 1999; De Groote 2002). Surveys conducted between 1995 and 2002 indicate that farmers in Kenya use several insecticides (mostly trichlorophon, fenitrothion, permethrin, and Bulldockä) and local technical knowledge (e.g., ash, soil, chilies, plant products) for stem borer control, while some farmers take no measures to control stem borer.

What is resistance? Why are stem borers likely to develop resistance?

Insecticide resistance is the ability of an insect to survive a dose of insecticide that would kill a normal, susceptible insect population. Resistance is one of the evolutionary products of pesticide application (Georghiou 1990; Oppernoorth 1976). It reflects the changing patterns of chemical usage over the past years. As a result of continuous pesticide use, insects develop some means or mechanisms to overcome effects of a toxin (Oppernoorth 1976). By 1984, there were 600 recorded cases of pest resistance to pesticides (Georghiou 1990). Research conducted by several scientists over the past 10 years indicates that insects are capable of developing resistance to Bt toxins (Tabashnik 1994). Stem borers are likely to develop resistance to pesticides because of their short life cycle and high reproductive rate (Unnithan 1987).

Mechanisms of insect resistance

Mechanisms of insect resistance reported in the literature include

- Changes in enzyme activity of insects resulting in a decrease in their sensitivity to toxins (Oppernooth 1976).
- Breakdown of enzymes that are involved in neurotransmission, e.g., acetyl-choline esterase, which hydrolyses acetylcholine (Oppernooth 1976).
- Increased ability of enzymes to detoxify pesticides making them less effective (Oppernooth 1976).
- Reduced binding of Bt toxin to mid-gut epithelium, which is the primary mechanism of Bt resistance in insects (Tabashnik 1994).

Insect resistance management (IRM) strategies

The most important step in dealing with the problem of resistance is to reduce the selection pressure on the pest population. Insect resistance management strategies include methods such as use of high dose toxin to kill all resistant homozygotes, use of mixtures of toxins targeting different receptors, rotation of Bt and non-Bt seed, and providing an untreated area as a refugia (Mallet and Porter 1992; Mc Gaghney et al. 1992; Mc Gaghney and Whalon 1992; Whalon and Norris 1996). The primary strategy for delaying the build-up of insect resistance to transgenic crops is to provide a refuge of host plants that do not produce the Bt toxins. This strategy provides susceptible insects to mate with resistant ones that have emerged from Bt maize fields, thereby maintaining resistance alleles in a heterozygous state. For example, in the United States, an area of 20% refugia (non-Bt maize) is recommended.

Goal, rationale, and objectives of the IRM study

To counter the buildup of resistance by the borers to Bt maize, the IRMA project is developing varieties that carry multiple forms of resistance: multiple Bt genes and combinations of Bt genes as well as conventional resistance. A borer population would have to develop multiple resistances rather than a single resistance to a single Bt toxin. In addition, management strategies are being developed, with the help of farmers that maintain populations of nonresistant borers that will breed with potentially resistant borers and limit the buildup of resistant populations. The aim is to produce a durable IRM strategy that incorporates both vertical resistance mechanisms (through the "pyramiding" or "stacking" of resistance genes), development of refugia, and horizontal resistance through conventional crop development and agronomic measures. To be accepted by farmers, IRM strategies must conform to existing cropping systems, and the refugia crops must be economically viable and socially acceptable to those making the management decisions at the farm level. The objectives of the study were to

- Identify suitable alternate hosts which can serve as a refugia for Bt maize in different agro-ecological zones within Kenya.
- Estimate and document % area covered by already established potential alternative hosts of major stem borer species which may be recommended for use as natural refugia.

To quantify existing refugia and identify where interventions need to be taken, research in three areas is ongoing: characterize host suitability using field trials and insect bioassays, farm surveys to characterize percent area covered by different alternate hosts, and map percent refugia at a district level to identify regions where structured refugia and future are necessary.

Materials and methods

Evaluation of recommended forages and maize for stem borer oviposition, survivorship, fitness, and development time

Thirty (30) different genotypes, including improved napier grasses, giant panicum, sorghum, and maize, were evaluated in four locations (Kitale, Kakamega, Embu, and Mtwapa) for four seasons (2001-2003), using a randomized complete block design replicated three times. Plot size was 5 m x 5 m giving a plant density of 50 plants (spaced 1m x 0.5m) for napier grass and 100-150 plants (spaced 50m x 30cm) for sorghum and maize. Columbus grass, Sudan grass and giant setaria were drilled and later thinned. All plots were bordered by a single row of commercial maize. Maize varieties used as borders were; H614D (Kitale), H622 (Kakamega), PH4 (Mtwapa), and H513 (Embu). Grasses were cutback two weeks prior to planting maize and sorghum varieties. Three weeks after planting maize, 10 pupae of one borer species were located at the intersection of four plots to make a total of 25 release points within the experimental plot to provide a uniform level of artificial infestation. The pupal species used in each location were the predominant species in the area (*B. fusca* in Kitale and Kakamega, *C. partellus* in Embu and Mtwapa). Three weeks after pupal placement, the numbers of plants showing larval feeding damage were counted within the plot. The pupal emergence was monitored by counting the pupae remaining in the containers. Separate counts on the number of maize border plants showing larval feeding were recorded. Scoring was repeated once again three weeks later. Data recorded included: percent of plants damaged by borers, number of exit holes, tunnel length, and yield (grain and fodder).

Bioassay for larval development rates and fecundity

Bioassays were conducted on *C. partellus, B. fusca, S. calamistis,* and *E. saccharina* in the laboratory at KARI-Kitale. Eggs of the four insect species were reared at KARI-Katumani insectary using an artificial diet. Genotypes used within the field trials were screened using insect bioassays in order to define development time and reproductive potential of the above species under ambient laboratory conditions. Napier and other grasses were cutback and maize and sorghums were planted at four-week intervals to ensure the availability of healthy tissue. Each genotype was infested with 30 neonate larvae and replicated three times. Larval survivorship and weight were recorded every seven days. Days taken from neonate stage to pupation were recorded for each pupae. Data was also collected on egg production and fertility (number hatching).

Characterizing maize cropping systems in different agroecologies in Kenya to estimate the potential of natural refugia

A questionnaire was prepared, pre-tested, and modified. The questionnaire was then used to interview farmers in 15 districts to estimate the area planted to suitable alternate hosts as well as characterize the farming system. Sampling was stratified to ensure representation of both commercial and small-scale farmers, with 20-40 interviews being conducted in each district.

Results and discussion

Evaluation of recommended forages and maize for stem borer oviposition, survivorship, fitness and development time

Results from the 2001 long rains indicate higher borer damage rating and exit holes in all sorghum varieties screened, including Pioneer maize varieties, H614D, H622; napier varieties Kakamega1, French Cameroon, Uganda boarder, Mariakani,16837; and Columbus grass (Table1). In 2002 and 2003, sorghum and maize had more borer exit holes while napier grass had very few.

Table 1. Summary means for different damage and plant performance parameters for three maize growing environments (Kakamega, Kitale Mtwapa 2001)

	Damage rating	Exit holes	Leaf force	Damaged plants	Tunnel length	Shoot / stem	Field yield	Est. moth production
	1-5 Score	No.	g-force	No.	Cm	No.	t/ha	No.
Bana	2.09	0.85	72.2	50	1.37	2.70	10.90	11308
Clone 13	2.02	0.93	79.0	39	2.51	2.33	8.41	14712
Columbus grass	2.07	1.02	64.8	56	7.14	1.39	2.56	406864
French Cameroon	2.51	1.15	85.8	58	2.99	2.09	10.41	19135
Giant panicum	1.83	0.20	80.9	16	0.65	2.31	1.65	1832
Gold Coast	2.17	1.79	71.0	71	3.99	2.27	9.08	31441
Kakamega 1	2.32	1.26	75.3	75	1.44	2.25	9.00	22711
Kakamega 2	2.04	1.30	87.0	49	4.01	2.13	4.52	20549
Kakamega 3	2.14	1.10	82.3	33	2.38	2.04	9.65	18187
Maize H614D	2.2	3.72	76.7	52	13.61	1.19	1.90	136977
Maize H622	2.38	2.36	74.0	45	8.61	1.254	1.26	81975
Maize pioneer	2.42	2.82	64.8	47	7.16	1.28	1.54	121163
Pearl millet	2.13	1.00	73.2	32	5.28	1.97	1.23	52000
Seredo	3.05	2.93	54.1	32	15.23	1.37	1.29	148226
Sorghum 2 Brown	3.08	3.54	59.4	53	16.40	2.16	1.65	196119
Sorghum 3 Red	2.75	6.92	59.0	36	24.96	1.55	1.48	364578
Sorghum 4 Brown	2.68	6.74	59.1	42	23.14	1.61	1.11	346204
Sorghum 1White	2.72	3.62	55.0	23	19.53	1.45	0.43	187384
Sudan Grass	2.04	0.59	58.9	68	4.43	1.40	1.93	246090
Uganda Border	2.19	2.06	70.1	28	2.78	2.31	14.05	28573
Total	**2.17**	**1.91**	**71.5**	**39**	**6.49**	**2.12**	**4.41**	**93595**
LSD(0.05)	**0.64**	**3.01**	**2.0**	**43**	**10.80**	**2.70**	**3.16**	**39200**

Results from the 2002 long rains indicate that moth production from napier and wild grasses is approximately 50% of that found in maize (Table 2). However, during the short rains there were no significant differences recorded for moth production between the different crop classes. This could have resulted from the napier and wild grasses requiring a season for establishment before reliable measurements of oviposition preference and progeny production could be evaluated. Sorghum varieties and maize consistently produce more moths.

Table 2. Relative insect production potential from different crop groups

Group	Long rains	Moth production ratio Short rains	Combined
Napier	0.51	0.97	0.56
Grasses	0.41	0.95	0.43
Sorghum	1.20	1.25	1.19
Maize	1.00	1.00	1.00

Bioassay for larval development rates and fecundity

Larval weight gain was generally greatest for the two preferred hosts, sorghum and maize (Table 3). However, for *B. fusca* and *S. calamistis*, giant setaria showed the greatest gains in larval weight.

Bioassay for larval development rates and fecundity

Larval weight gain was generally greatest for the two preferred hosts, sorghum and maize (Table 3). However, for B. fusca and S. calamistis, giant setaria showed the greatest gains in larval weight.

The bioassay results show that maize is the best host for the production of viable eggs. Maize also demonstrated the shortest life cycle, with napier grasses showing the longest development time (Table 4).

Table 3. Average weight of four species of stem borer reared on four groups of hosts under controlled conditions, Kitale, 2002

Crop	*Chilo partellus*	*Busseola fusca*	*Sesamia calamistis*	*Eldana saccharina*
Wild grasses	0.018	0.038	0.035	0.015
Maize	0.023	0.025	0.020	0.015
Napier	0.017	0.026	0.014	0.012
Sorghum	0.024	0.025	0.021	0.015
Overall mean	0.020	0.026	0.020	0.013
LSD(0.05)	0.009	0.009	0.003	0.002

The bioassay results show that maize is the best host for the production of viable eggs. Maize also demonstrated the shortest life cycle, with napier grasses showing the longest development time (Table 4).

Table 4. Life cycle and reproductive potential for *Busseola fusca* and *Sesamia calamistis* reared on different classes of alternate hosts under laboratory conditions, Kitale, 2002

Crop type	*Busseola fusca* Life cycle days	*Sesamia calamistis* Survival %	Egg production No.	Life cycle days	Survival %	Egg production No.
Napier grass	64.5	2.8	5.0	60.9	3.3	93.0
Local sorghum	60.3	37.8	184.8	56.5	13.3	67.0
Maize	53.2	18.5	246.6	51.7	27.5	629.3

Characterizing maize cropping systems in different agro-ecologies in Kenya to estimate the potential natural refugia

Kwale District had a maize equivalent refugia of 18%, comparable to the 20% recommended for commercial maize in the USA. Kilifi and Kwale Districts at the coast have a diversity of cropping systems and appear to have adequate refugia at the district level of 18% (Table 5). Villages that may not have sufficient refugia, such as Chilulu (10%), are likely to be sufficiently close to communities that have large refugia, such as Kaloleni (50%). There is sufficient refugia during the short rains compared to long rains (Figure 3a and b).

Table 5. Vegetation survey results for Mombasa/Kilifi Districts to assess the availability of natural refugia within the existing cropping system

				Loss due to borers		Natural refugia	
Location	Total area Ha	Area planted Ha	Maize area %	No control %	Control %	By farm %	By area %
Chilulu	3.0	1.6	44	64	19	12.9	10.1
Kaloleni	2.7	2.5	36	62	27	37.2	50.3
Dzombo	4.5	4.0	52	76	25	13.2	10.6
Mtwapa	4.0	2.4	18	53	12	22.1	19.1
Township	1.8	0.9	28	62	15	41.0	35.4
Ziani	3.7	2.5	40	63	19	10.5	12.2
Means	3.3	2.3	36	63	20	22.8	22.9
				Estimate of District			18.2
				Desired refugia (min.)			20.0

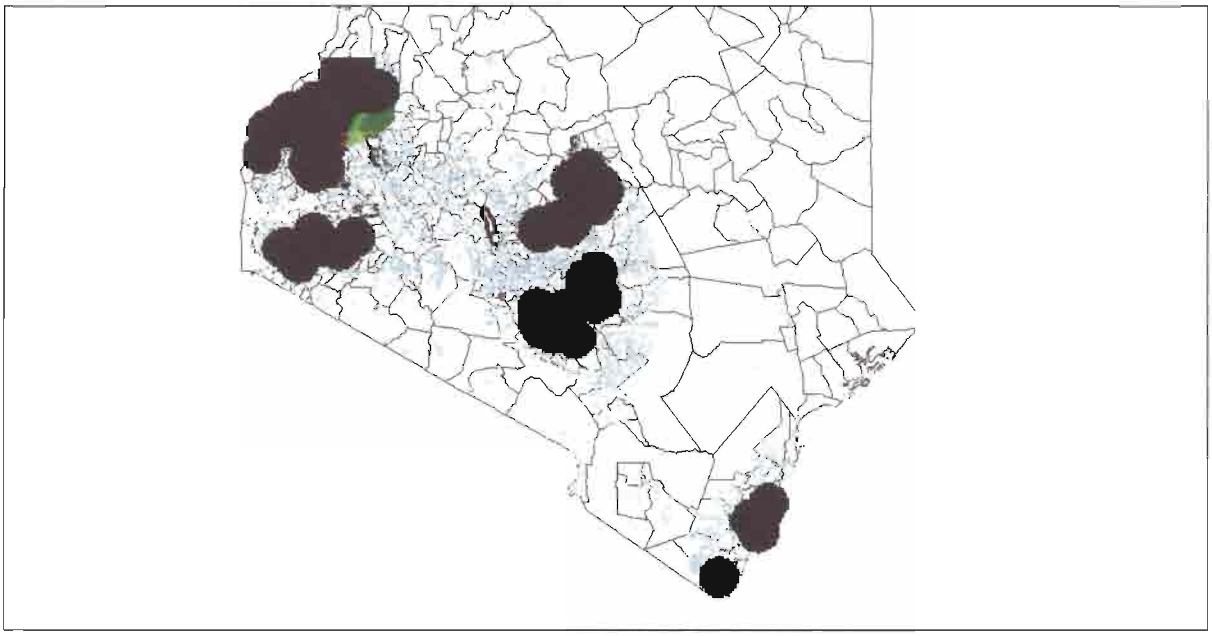


Figure 3a. Maps of refugia distribution in Kenya, "short rains" based on farmer surveys

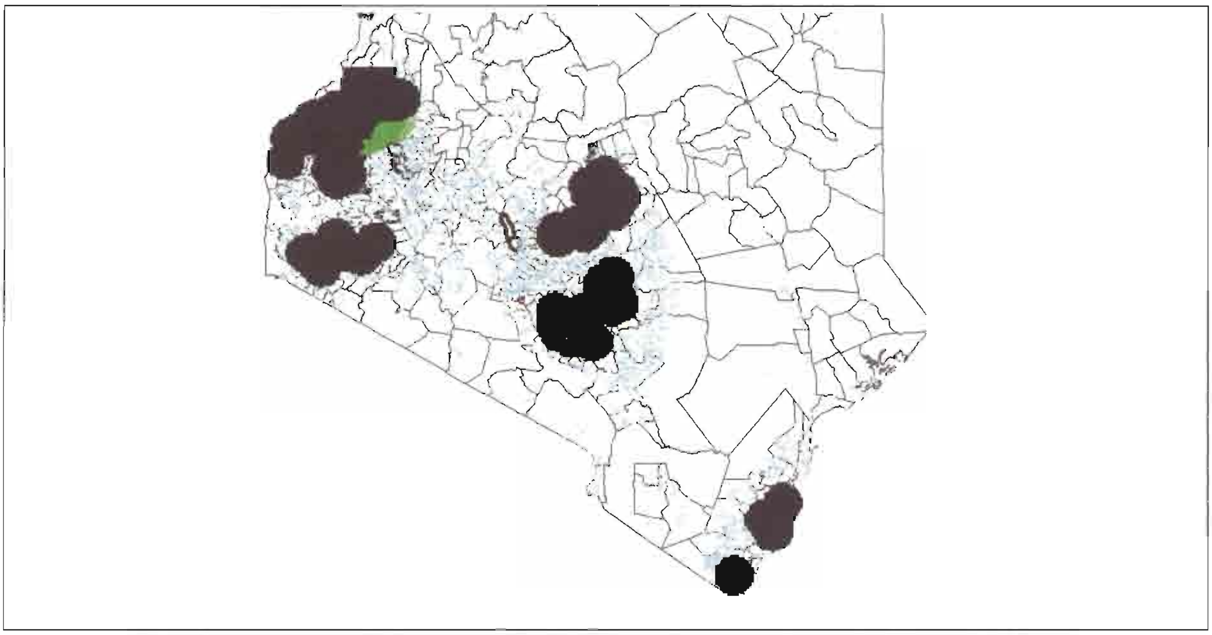


Figure 3b. Maps of refugia distribution in Kenya,"long rains" based on farmer surveys

Future Research

1. Based on observations during the vegetation surveys, considerable diversity in sorghum was found as well as giant panicum. Collections have been made to quantify the variation in moth production within these two groups of alternate hosts.
2. Continue developing IRM strategies suitable for Kenyan farming systems (including open pollinated maize varieties), with farmer participation (workshops and field trials).
3. Develop participatory monitoring and evaluation frameworks for Bt maize technologies.
4. Refugia survey data will be used to help generate Geographical Information System (GIS) maps to identify areas in Kenya where insect resistance is most likely to occur, to prioritize monitoring activities, and to be proactive in ensuring structured refugia are enforced in those regions with insufficient refugia.
5. Develop simple techniques for monitoring resistance developing to Bt maize.

2.2 Farming systems of the Coast Province

M. B. Muli, Agronomist, KARI-Mtwapa and P. Odhiambo, RELO Ministry of Agriculture Coast Province

Introduction

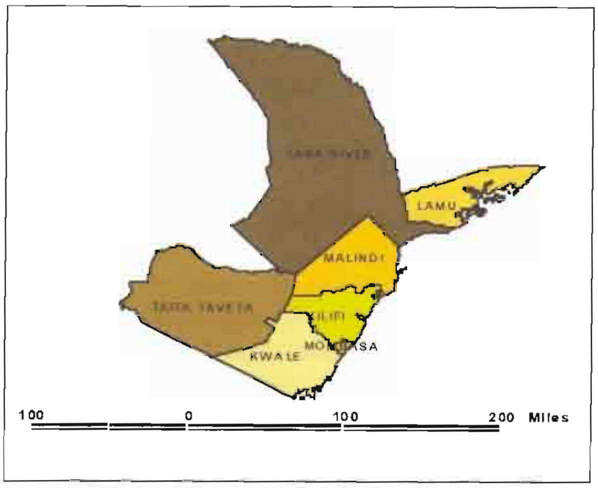


Figure 4. Map of Coast Province showing district boundaries.

The Coast Province of Kenya is located between latitudes 1° and 4° south and longitudes 38° and 41° east. It covers an area of approximately 84,000 sq. km and is divided into seven administrative districts: Kilifi, Kwale, Mombasa, Malindi, Taita-Taveta, Tana River, and Lamu. The largest part of the region lies in the coastal lowlands (CL), which is divided into five agroecological zones, namely CL2, CL3, CL4, CL5, and CL6. The region receives bimodal rainfall with annual averages ranging from 1,400 mm in CL2 to less than 400 mm in CL6. The rainfall is distributed over two distinct seasons: the long rains (April to July) and the short rains (October to December). The most common food crops grown in the region are maize, cassava, cowpea, sweet potatoes, and upland rice. Cash crops include: coconuts, cashew nuts, mangoes, citrus, tomatoes, watermelons, simsim, Bambara nuts, and cotton. The average maize yield is about 1t/ha, whereas improved varieties have a yield potential of up to 5t/ha. The region is a food deficit area, producing only 20% of its food requirement.

Major enterprises and cropping systems

Farmers in the Coast Province practice mixed farming. Perennial tree crops such as coconuts, cashew nuts, mangoes and citrus are intercropped with food crops (maize, cassava, and cowpea). Livestock grazing also occurs under these trees. Common livestock include: cattle (local zebu), goats, and poultry. Major cropping systems include: maize/cassava intercropping, mMaize/cassava intercropping with cowpea or green grams as a relay crop, maize/cassava/cowpea or green gram intercropping, maize/sorghum inter-cropping, sorghum/cassava intercropping and sorghum/cassava intercropping with cowpea or green grams as relay crops.

Cropping calendar

The cropping activity calendar for the Kenyan coastal lowlands includes land preparation that starts in late January and extends to early March (Table 6). This entails bush clearing and burning of the residue and/or seedbed preparation using either the local hoe (Kaserema) or oxen-drawn implements. Some farmers also use tractor-drawn implements for land preparation. Dry planting is not practiced in most

Table 6. Cropping activity calendar for coastal lowlands of Kenya

Crop	Jan-Mar	April	May-Jul	Aug-Sept	Oct-Dec
Cashew		Seed sowing, Transplanting seedlings		Weeding, Seed sowing	Harvesting
Coconut	Harvesting makuti, Weeding	Nut harvesting	Makuti harvesting	Nut harvesting, Weeding	
Cowpea			Planting, Weeding, Leaf harvesting	Grain harvest	
Cassava	Harvesting, Land preparation	Harvesting, Land prep., Marketing	Harvesting, Marketing	Weeding	
Maize	Land preparation	Planting	Weeding	Harvesting, Land prep., Planting	Planting, Weeding

Source: L. Otieno et al. (1994).

parts of the province. Cereal crops are planted at the onset of long rains, normally in late March or early April, although some of the farmers plant in May. Legumes, especially cowpea and green grams, are relay planted in late June. Weeding starts in May for the early planted crop and extends up to July. The last weeding doubles as land preparation for the relay crop. Harvesting is done late July to early September, after which a majority of the farmers store maize in cobs above the fireplace.

Labor and household food supply

Labor for on-farm activities is provided mainly by the farm family, with women providing the bulk of it. Demands for hired labor rises during weeding period. Payment for hired labor is either in the form of cash or exchange with foodstuff such as cassava or maize.

Food supply from family farms varies within the year depending on the season. Food harvested in September lasts in most cases up to December. A household food deficit situation typically occurs between January and July. The most critical period is between April and June, when there is heavy demand for family labor. Farmers cope with food shortages by bartering farm produce such as *makuti*, copra, and cashew nut for maize flour or cowpeas for fish. Off farm income from casual farm labor is also common in this period.

Crop production in the province by district

Crop acreages and production are summarized in tables 7-13. Maize, cowpea, and cassava are the major food crops grown in nearly all of the divisions of the Kwale, Mombasa, Kilifi, Malindi, and Lamu Districts. Rice is a major enterprise in Msambweni, Kaloeni, and Garsen Divisions of Kwale, Kilifi and Tana River Districts, respectively. Improved maize is mainly grown in Kwale, Kilifi, and Mombasa Districts (Table 7)

Table 7. Food crop area and production in Kwale District

	Division					Total	
Crop	Matuga	Kubo	Msambweni	Kinango	Samburu	Hectares	Tons
Maize	518	1333	2200	5199	1590	10840	7716
Rice	60	53	696	6	10	825	712
Sorghum	5	8	12	38	1.5	64.5	59
Millets	0.2	4	1	6	0	11.2	25
Cowpea	508	179	225	476	185	1573	594
Cassava	326	381	256	365	84	1412	11755

Source: Coast Province annual reports: 2000-2003

Table 8. Food crop acreage and production in Mombasa District

	Division			Total	
Crop	Kisauni	Likoni	Changamwe	Hectares	Tons
Maize	221	109	94	424	464
Rice	24	10	11	45	32
Sorghum	1.5	1	1	3.5	5
Millets	0	0	0	0	0
Cowpea	29	20	21	70	32
Cassava	60	55	74	189	1427

Table 9. Food crop acreage and production in Kilifi District

Crop	Division							Total	
	Kikambala	Bahari	Chonyi	Kaloleni	Ganze	Vitengeni	Bamba	Hectares	Tons
Maize	2375	3675	3029	2787	1680	2170	1328	17044	13586
Rice	14	5	50	310	0	0	0	379	158
Sorghum	0.6	12	2	7.5	2.5	6	25	55.6	13
Millets	0	0	0	0	0	0	0	0	0
Cowpea	1172	505	1327	658	103	470	335	4570	896
Cassava	750	382	2170	680	240	635	105	4962	35832

Table 10. Food crop acreage and production in Malindi District

Crop	Division			Total	
	Malindi	Marafa	Magarini	Hectares	Tons
Maize	6336	4161	7701	18198	13944
Rice	7.5	10	1	18.5	17
Sorghum	8.6	17.5	50	76.1	86
Millets	0.5	3.5	0	4	3
Cowpea	288	884	207	1379	877
Cassava	1516	179	356	2051	24217

Table 11. Food crop acreage and production in Tana River District

Crop	Division						Total	
	Kipini	Garsen	Galole	Wenje	Bura	Madongo	Hectares	Tons
Maize	295	338	87	93	333	14	1160	1422
Rice	66	548	28	38	3	1	684	1093
Sorghum	4	1	3	2	2	0	12	6
Millets	2	0	0	0	1	0	0	0
Cowpea	85	72	41	40	41	12	291	156
Cassava	15	13	16	12	1	3	60	384

Table 12. Food crop area and production in Lamu District

Crop	Area (Hectares)	Production (Tons)
Maize	4750	3826
Rice	38	20
Sorghum	222	151
Millets	28	15
Cowpea	772	574
Cassava	450	4502

Table 13. Improved maize acreage in the Coast Province of Kenya

District	Total maize acreage Hectares	Acreage under improved maize Hectares	Proportion of improved maize %
Kwale	10840	944	8.7
Mombasa	424	295	69.6
Kilifi	17044	3000	17.6

3. Reports from Coast Province Districts on Major Fodders/Forages Grown by Farmers: Acreages and Yields

3.1 Kwale District

F.M. Kangunu, District Livestock Production Officer, Kwale District

Introduction

Land area	8,322 km^2
Water surface	65 km^2
Agricultural land	7313 km^2
Non-agricultural land	1009 km^2
Human population	496,133 (1999 census)
No. of farm families	87,512
Average farm size	10.8 ha
No. of divisions	6
No. of locations	37
No. of sub locations	87
Altitude	0 - 462masl
Livestock population figures (2003)	
Dairy cattle population	2,478
Beef cattle population	167,746
Sheep population	73,705
Goats population	202,774
Dairy goats	200
Dairy goat crosses	60
KDPG	32

Land area by ecozone:

L2 (lowland sugarcane)	235 km^2
L3 (coconut–cassava zone)	953 km^2
L4 (cashew nut–cassava)	897 km^2
L5 (lowland livestock millet)	2,342 km^2
L6 (lowland ranching zone)	2,886 km^2

Climate

The district has a monsoon type of climate that is hot and dry from January to March. The rainfall is bimodal with the long rains in March/April and continuing until July and the short rains during October and November. The rainfall decreases from the coastline to the hinterland. The precipitation is 900-1,500 mm/yr along the coastline and 500-600 mm in the hinterland, with a reliability of 60%.

Fodder and pasture growing

Fodder and pasture growing and production follow the rainfall pattern. Thus, most pastures/fodder grow during the long rains (March–July). During the short rains very little pasture is established though regeneration of harvested areas. Natural vegetation cover varies from zone to zone with a variety of trees and grasses specific to each ecological zone.

An increase of fodder establishment is hampered by drought that causes total loss of fodder in dry months and unavailability of natural pastures during the wet months. The average farmer has 1-2 acres of napier, and 30-50 legumes trees.

District estimates of acreage for various grown fodder

Type of fodder	Acreage (District)	Production/acre (ton. DM)
Napier	500 ha	5-6
Fodder trees	50 ha	4–5 (*Gliricidia Spp*, leucaena Spp. etc.)
Fodder legumes	5ha	? (*Clitoria, Siratro, Dolichos lablab* & *Mucuna* Spp.)

Estimated crops acreage – (2003) of other crop residual used as livestock feeds

Sorghum	-	104.2 ha
Millet	-	13.5 ha
Local maize	-	10178.5 ha
Improved maize	-	1081.5 ha
Sweet potato vines		318.4 ha

Development of pasture and fodder improvement and extension projects

Pasture and fodder development projects over the years have aimed to improve dairy production. These programs have focused on promotion of grasses and legumes for fodder, mainly *Cenchrus siliaris, Eragrostis superba* (for rangeland reseeding), *Chloris roxburghinana, Enteropogor machrostachyus*, napier/ Bana, giant panicum (used for zero grazing/intensive), *Setaria* Spp. (for dairy farming), Rhodes grass (*Chloris gayana*), *Leaucana* Spp., and *Gliricidia* Spp.

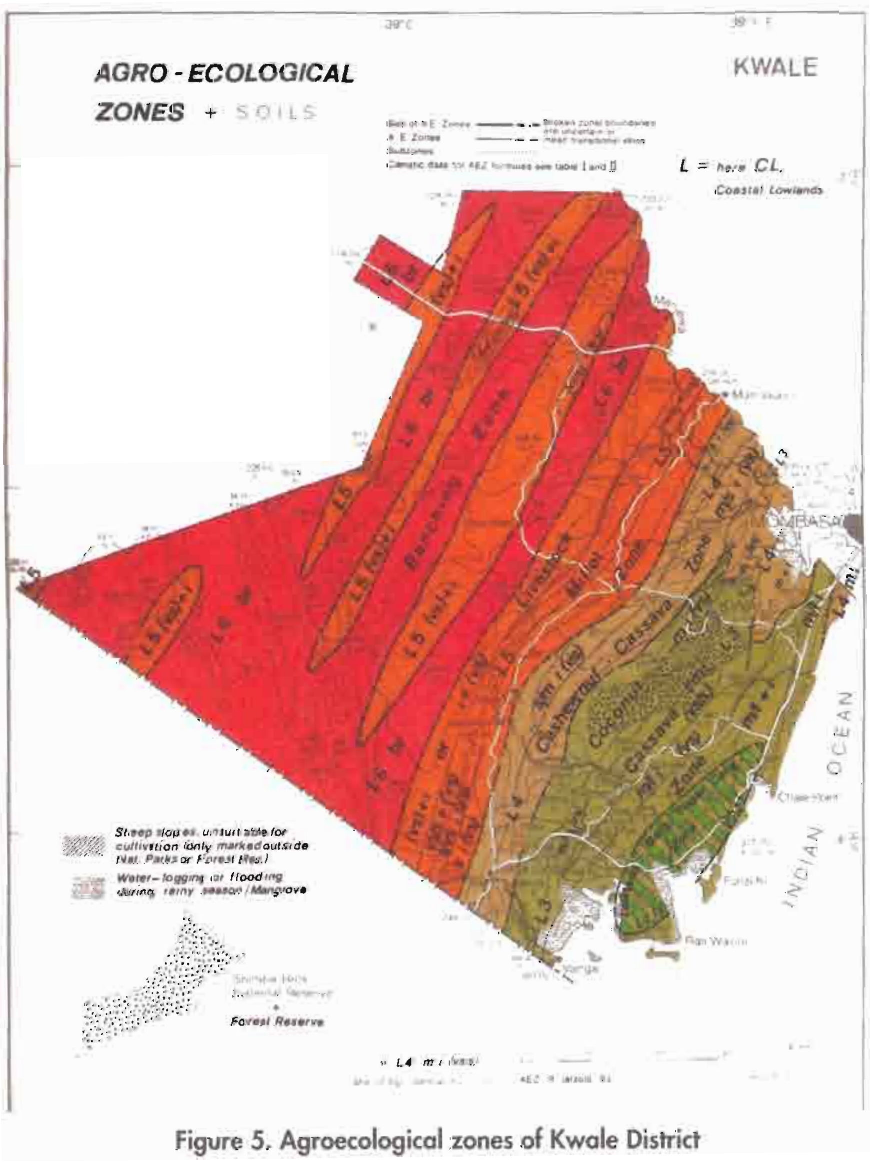


Figure 5. Agroecological zones of Kwale District

Under the dairy project, a number of fodder crops were tested for adaptability, including clitoria, guatemala, Bana, French Cameroon, leaucana, gliricidia, mucuna, siratro and sweetpotato vines in four dairy farmer groups, namely Mwembezembe, Patanani, Mazumalume and Vuga. After testing, clitoria and siratro (both drought resistant), *Dolichos lablab*, mucuna, and sweetpotato vine fodder crops showed good performance and were therefore recommended for Kwale District. The fodder legumes recommended were Gliricidia and Leuceana. Gliricidia had higher growth vigor but was less palatable. Leucana was palatable, drought tolerant, and higher yielding, and was available along road reserves. Among the napier, Bana grass, clone13, and Guatemala were the best. French Cameroon and cow candy sorghum were preferred by stem borers over other grasses. At Patanani Farmer Field School (FFS), it was observed that maize planted near a plot of cow candy sorghum was not infested by stem borers, while the cow candy sorghum supported a large population of stem borers. Napiers gave 2–3 harvests per year. Drought necessitated reestablishment of napier as it suffered a total loss. However, irrigating napier increased the number of harvests to 4–5/yr, as observed with farmers in Likoni.

3.2 Mombasa District

O.M. Mwanzau, District Livestock Production Officer, Mombasa District

Introduction

Most farmers in the Coast Region, especially those keeping the indigenous livestock (cattle, sheep, and goats) rely on natural pastures as sources of feed. However, those with small- or large-scale enterprises in zero grazing systems do grow various fodder crops. This is true in Mombasa District, where the faming systems are characterized by smallholder subsistence farming. The fodders include napier grass (*Pennisetum purpureum*) leuceana (*Leuceana leucocephala*) gliricidia (*Gliricidia sepium*) blue pea (*Clitoria ternatea*) and mucuna (*Mucuna pruriense*), among others.

Livestock population

Various livestock types are found in Mombasa District and their population varies with land size as shown in Table 14

Table 14. Livestock population and distribution in Mombasa District

	Division				
Enterprise	**Island**	**Kisauni**	**Changamwe**	**Likoni**	**Total**
Dairy cattle	5	2526	940	105	3576
Zebu cattle	-	2467	1170	462	4099
Dairy Goats	5	36	22	25	88
Indigenous Goats	273	6421	3540	1327	11561
Hair Sheep	38	1062	592	25	1717

Source: DLPO Annual Report 2003

Table 15. Land use and potential in Mombasa District

Division	Arable land (Km≤)	Non-arable land (Km≤)	Total area (Km≤)
Island	0.1	21	21
Kisauni	65.5	61	126
Changamwe	20.0	51	71
Likoni	13.9	50	64

Most common fodders

Napier is the fodder most preferred by farmers. Farmers have cited the following reasons: ease of establishment, drought resistance, alternative use as silage, convenience of cutting and carrying, and high forage yield. Leucaena is the most preferred among legumes and farmers have cited the following reasons: easy to establish, high milk production when used as supplement to grass fodder, can be established with napier grass as well as food crops, and once established it is very resistant to drought.

Table 16. Major fodder/forages grown in Mombasa District

Common Name	Scientific Name	Varieties	Area ha	Distribution per Division ha	Utilization	Area per Household Ha
Napier Grass	*Pennisetum purpureum*	Bana, Clone13, French Cameroon, Uganda Hairless, Gold Coast	23.0	Island – 0 Kisauni-18 Likoni-4.0 Changamwe–1.0	Whole, Chopped, and or Silage	0.4
Leucaena	*Lecaena leucocephala*	Lucaena	1.0	Island -0 Kisauni – 0.80 Likoni - 0.15 Changamwe – 0.15	Whole, Chopped	Only 3 farmers have planted
Gliricidia Blue Pea Alfalfa Mucuna	*Gliricidia sepium* *Clitoria ternatea* *Medicago sativa* *Mucuna pruriense*	Gliricidia Clitoria Lucerne Mucuna	1.0 All	Kisauni – 0.80 and Changamwe – 0.20	Whole, Chopped	Only 3 farmers have planted
Maize	*Zea mays*	Improved local	194 390	–	10 acres as fodder grown by one farmer	
Sorghum	*Sorghum vulgare*	Seredo and Serena	2.0	Kisauni		

3.3 Lamu District

Fred Jefa, District Livestock Production Officer, Lamu District

Introduction

Lamu District covers 6,474.7 sq. km, of which 30 sq. km are bodies of water. It borders the Indian Ocean to the South, Tana River District to the southwest, Ijara District to the north and the Republic of Somalia to the northeast. It lies between latitudes 1° 40′ and 2° 30′ south and longitude 40° 15′ and 40° 38′ east. Lamu is generally flat and the elevation is 0-50 masl, with 130 km of coastline.

Administratively Lamu is divided into seven divisions, 23 locations, and 40 sub-locations with a human population of 72,686. Kizingitini has the highest population density with 332 people per sq. km, while Kiunga has lowest with 2 people per sq. km.

The district has two constituencies: Lamu West, which covers Amu, Hindi, Mpeketoni, and Witu Divisions; and Lamu East, which covers Faza, Kizingitini, and Kiunga Divisions.

The district receives a bimodal rainfall of 550 mm to 850 mm annually, with long rains starting in mid-April and short rains in November-December. Temperatures range from 23°C to 32°C, with a mean around 28°C.

The agriculture and livestock sector in Lamu District

After fishing, agriculture is the second most important economic activity in Lamu District, accounting for more than Ksh. 1 billion annually. The sector provides employment to more than 60% of the people, either directly or indirectly. It also provides food and nutrition for the people and raw materials for agroindustries.

The district is divided into two zones: the rich agricultural and livestock zone in the mainland (mainly settlement schemes) and fishing and marine zones (the Island). The rich agricultural and livestock zone is composed of Mpeketoni, Witu, and Hindi divisions and along the Mokowe-Garsen road. These settlement areas have land parcels ranging from 10 to15 acres. Agricultural activities are concentrated within Mpeketoni, Witu, and Hindi Divisions where farmers practice mixed and commercial farming. The rest of the district is mainly subsistence farming. The main crops grown include maize, cassava, sorghum, pigeon

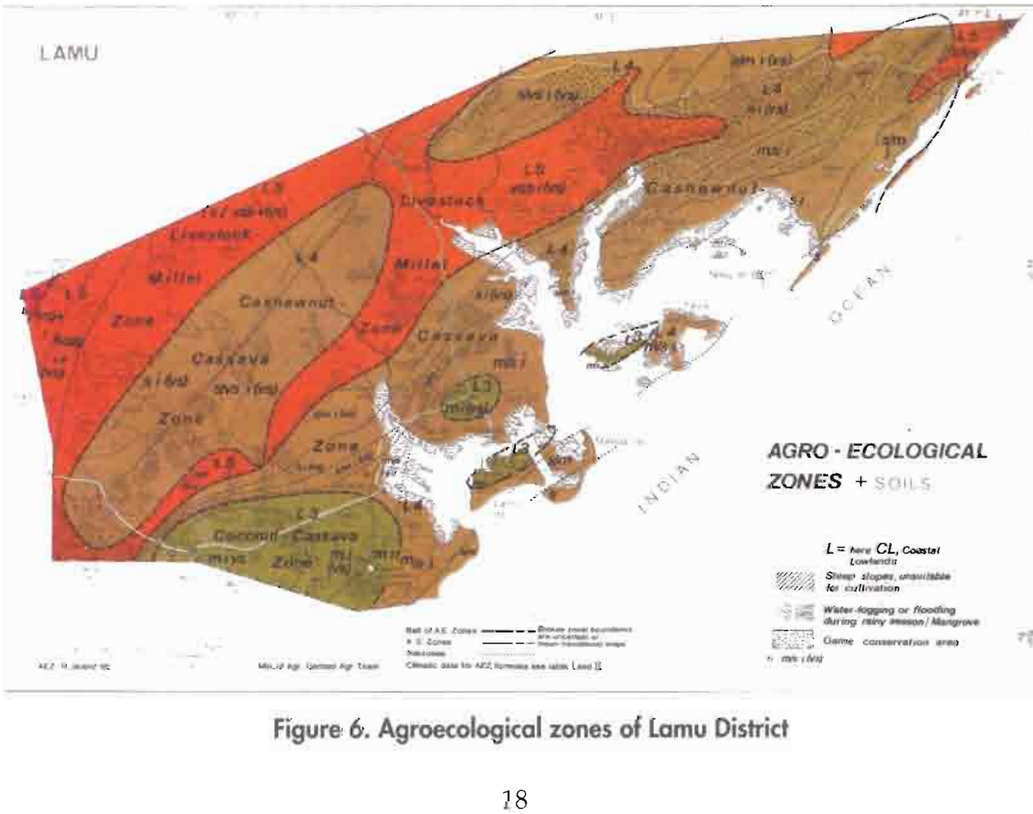


Figure 6. Agroecological zones of Lamu District

pea, cotton, bixa, cashew nut, mangoes, citrus, bananas, and vegetables. Maize is the chief food crop grown in the district, grown on 4,000–5,000 ha annually, with grain yields of 1 t/ha. The popular varieties include PH4, PH1, and local varieities. Maize is usually intercropped with pulses such as cowpea, green grams, dolichos, and common beans.

Major livestock enterprises in Lamu District

Livestock in Lamu includes indigenous breeds of cattle, goats, sheep, poultry, and donkeys (for transport). A few cross-bred cattle and dairy goats are found in the settlement schemes of Mpeketoni and Amu Island. More than 80% of the livestock are held by pastoralists.

Fodder/forages and pastures

Natural pastures are the main source of livestock feeds in the district. About 159,000 ha are under natural pastures. Various fodder plants were introduced in the district through the National Dairy Development Project and had a very positive impact; these include napier grass, clitoria, leucaena, gliricidia, and dolichos.

The department is focusing on farmer managed forage bulking through the FFS approach. These fodders are planted as a pure stand block, along boundaries, or intercropped (e.g., napier with clitoria). Feed storage in the form of hay or silage is rare.

Farmer preferences for forage are based on drought tolerance, palatability, high yields, ability to be planted with napier, ease of establishment, availability of planting materials, and pest resistance (especially for the *Leucaena Psyllid* problem).

Constraints in fodder/pastures production in Lamu District

The noxious weed known as doum palm *Hyphaene coriecae* or locally known as marara, and in Kiswahili as mkoma, is dominant in all ranches and even in crop fields. This weed is extremely expensive and difficult to control even through burning and may require research intervention. Low soil fertility and drought, particularly on the islands of Amu, Faza, and Manda makes it difficult to establish napier grass, while production of forages in these areas could greatly help dairy farmers.

Table 17. Livestock Population Estimates in Lamu district

Type	Witu	Mpeketoni	Hindi	Amu	Faza/Kingitini	Kiunga
Beef	38850	21110	1350	515	1997	2500
Dairy	5	1540	20	1210	35	0
Goats	25015	50000	3900	2500	2000	1000
Sheep	8600	9104	260	500	1370	5000
Poultry	36000	87000	7000	4800	11650	100
Donkeys	75	40	100	3000	1000	–

Table 18. Types of fodder/forages and pastures in Lamu Distric

Type of feeds	Distribution
Natural pastures: *Hyparrhenia cymboria, Panicum maximum, Digitaria diagnolis, and Dactyloctaenium aegypticum*	About 159,000ha mainly in ranches. With a Livestock carrying capacity of 5-6 Ha./L.U.
Fodder/Forages: Napier grass,Clitoria, Mucuna,Lucaena, Gliricidia,Dolichos, and Potato vines	48 acres of Napier grass. 25 acres of Legumes forages. A bout 100 farmers own < 0.5 acres of established fodder/forages each. Yields are very low and hence not enough surpluses to be conserved.

3.4 Kilifi District

A Brief Report on Pasture and Fodder Development in Kilifi District

Martin Okonji, District Livestock Production Officer, Kilifi District

Introduction

Kilifi District lies north of Mombasa and borders Kwale to the southwest, Taita Taveta to the west, and Malindi to the north (Figure 7). The District has a total area of 4,779.2 sq. km and an estimated population of 544,303 persons distributed within 90,000 households (1999 population census report). Kilifi District has seven Administrative Divisions namely: Bahari, Chonyi, Ganze, Kikambala, Vitengeni, Kaloleni, and Bamba.

Agroecological zones of Kilifi District

- ***Coconut-cassava zone (CL3):*** This zone has the highest potential for crops and spreads along the coastal uplands and low-level coastal plains. Major farming activities include tree cropping (mango, citrus, cashew nuts, and coconuts), vegetables (chilies, brinjals, okra, etc.), food (maize, bananas, cowpeas, green grams, etc.) and upland rice. Dairy also does well in this zone. It has an average precipitation of 1,300 mm/yr and mean annual temperature of 24°C (Figure 8)
- ***Cashew nut-cassava zone (CL4):*** This zone stretches northwards along the coastal plain up to Sokoke forest. It has an average precipitation of 900 mm and mean annual temperature of 24°C. It has agricultural potential with some crops as in CL3, but with less production.
- ***Livestock-millet zones (CL5):*** This zone has lesser potential with precipitation of 700-900 mm, and is suitable for dryland farming and livestock ranching.
- ***Lowland ranching (CL6):*** This zone varies in altitude (90-300 masl) with mean annual temperature of 27°C and annual precipitation of 350-700 mm. Major activities include ranching and wildlife.
- ***Coconut-cashew nut-cassava (CL3-CL4):*** This zone is mainly found in Bahari Division and is the smallest of all zones. Its altitude is 300-310 masl with mean temperatures of 27°C and annual precipitation of 900 mm/yr. The area has potential for those crops grown in CL3 and CL4.

Table 19. Summary of livestock production in Kilifi district

Livestock Type	Bahari	Chonyi /Kikambala	Vitengeni	Ganze	Bamba	Kaloleni	TOTAL
Beef	14400	3000	20400	18500	33900	40000	113805
Dairy	16410	10425	1792	1325	114	2630	33101
Goats	14500	4447	13012	16200	53200	17200	123059
Sheep	4000	1970	2659	3180	8000	5300	25909

Table 20. Maize and sorghum production—long rains 2004 in Kilifi district

Division	Maize achieved (ha)	Maize expected yields (tons)	Sorghum established (ha)
Bahari	1542	800	7
Chonyi	2450	2430	0.5
Kikambala	1730	1730	0
Ganze	1050	525	0.5
Bamba	915	415	30
Kaloleni	1366	688	33
Vitengeni	2260	1130	6
TOTAL	11313	7738	77

Fodder production in Kilifi District

Four farmer field schools were involved in the production of fodder under the collaboration of KARI and GoK through KARI's ATIRI program and the on-farm evaluation of dairy technologies programs (Table 21).

Table 21. Groups of farmer field schools in Kilifi district with ATIRI projects

Division	Groups
Bahari Division	1. Mpendakula Women Group 2. Jilinde Youth Group 3. Tumaini Women Group
Kikambala Division	1. Shukurani Women Group

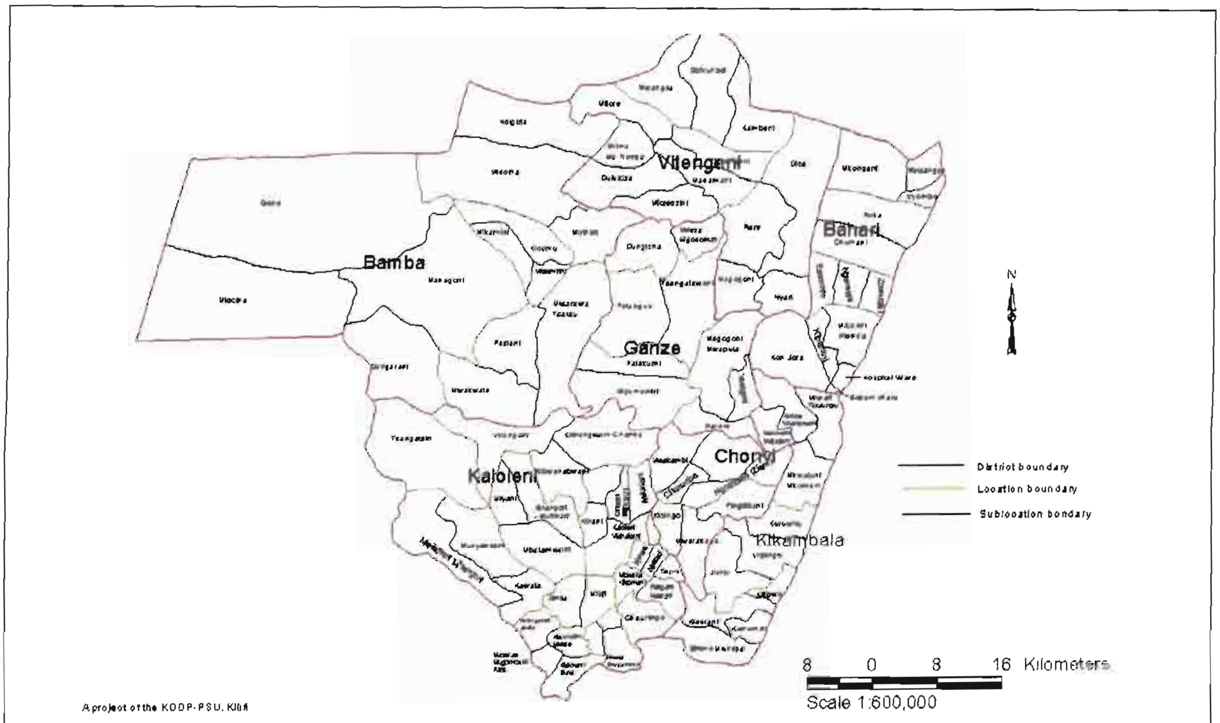


Figure 7. Map of Kilifi District

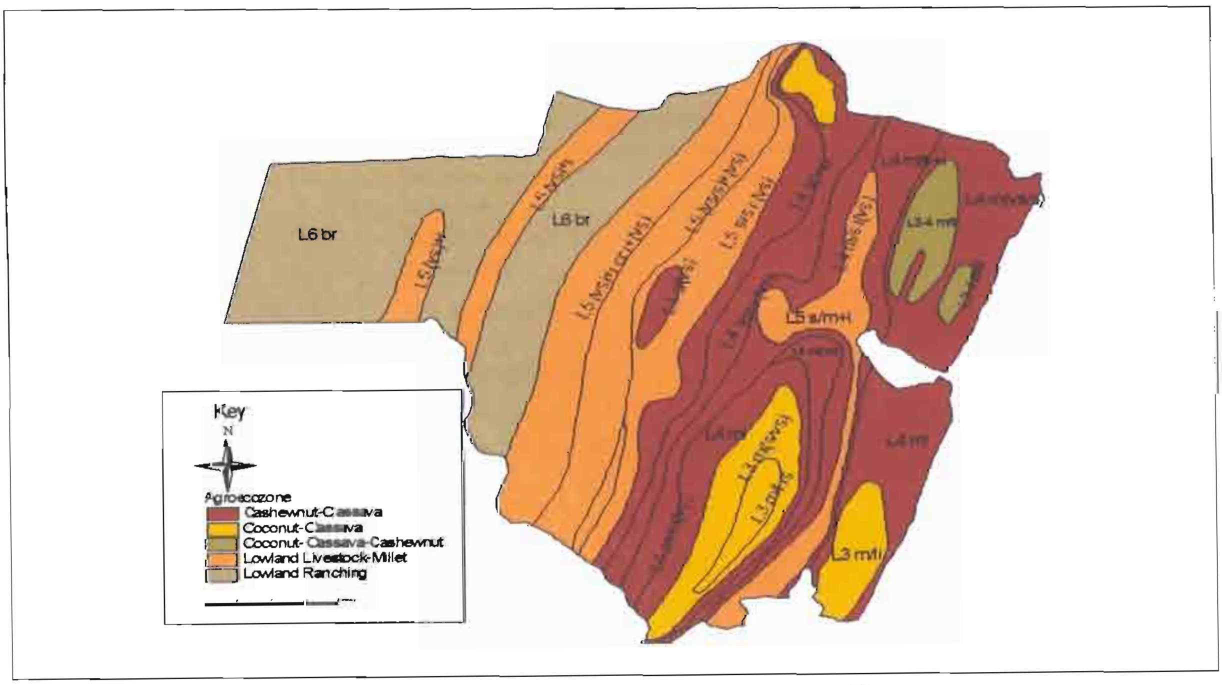


Figure 8. Agroecological zones of Kilifi District.

The groups were taught fodder establishment methods, harvest and utilization, and preservation and conservation methods. They carried out all these activities on their demonstration farms and some adopted them on their individual farms. The fodder produced were (i) napier grass, and legumes; (ii) tree legumes, specifically *Leucaena* and *Glyricidia;* and (iii) herbacous legumes, *Clitoria, Siratro, Mucuna,* and *Dolichos lablab*. The adoption rate was more than 60%, but due to the unreliable rainfall, most of the established fodder dried and required re-establishment.

Other materials (forage) fed to the livestock are crops and crop residues, farm weeds, and natural pastures. Crops and crop residues include maize stover, cassava (especially the Guzo varieties with leaves, stems, and the tubers utilized), cowpea leaves and plant residues, mango tree leaves and fruits, especially during the dry season, sweet potato vegetation, and banana stems during the dry period (although they have very little dry matter content and nutrients). Farm weeds used for feed include Wandering Jew, pigweed, and Kidunga ajeni (*Cenchrus spp*).

Table 22. Summary of fodder production situation in Kilifi district

	Division	Napier grass (Ha)	Tree and herd Legumes (Ha)
1	Bahari	30	8
2	Kikambala	25	5
3	Chonyi	18	1
4	Kaloleni	20	2
5	Ganze	3	1
6	Bamba	0	0
7	Vitengeni	8	1
	Total	**104**	**18**

Table 23. Main species of grasses found in Kilifi District

Grass	Remarks
1. *Panicum maximum*	Found in Bahari and Kikambala Divisions. Has more leaves and grows very fast.
2. Maasai love grass (Eragrostis spp.)	This is the most predominant in the Ranching zone of Kaloleni, Ganze, Vitengeni and Bamba.
3. African fox tail (*Cenchrus ciliaris*)	Found all over the district (but more in the Ranching zone)
4. Common Star grass (Cynodon sp.)	Found all over the district (but more in the more wet divisions).
5. *Hyparrhenia rufa*	Found in the Rocky areas (poor soils).

3.5 Malindi District

A bried report on pasture and fodder development in Malindi District
O.D. Morowa, District Livestock Production Officer, Malindi District

Table 24. Malindi District: background information

Division	Area	Farm families	No. Location	No. Sub Location	No. Few	Livestock population (Est.) Dairy	Beef	Sheep	Goats
Malindi	3,515	16,973	8	35	3	15,600	55,000	14,500	93,000
Magarini	728	11,341	3	9	2	5,000	38,000	4,000	32,000
Marafa	3,361	7,114	5	16	2	600	27,000	12,000	45,000
TOTAL	7,605	35,428	16	60	7	21,200	120,000	30,500	170,000

Pasture/Fodder

Table 25. Pasture grasses in Malindi district (production, management and utilization)

S/No.	Plant	Acreage (Ha)	Agronomy	Utilization	Experience
1.	Napier Malindi Magarini	 186 15	– Rain feed – Planting materials and cuttings (commonly used) and splits. – Proper weeding and manure application by few farmers	– Cut and carry – A 45 Kg sack/ animal/day – Ensiling by few farmers producing ten tones of silage.	– Bana grass is most commonly used followed by French Cameroon. – Manure application is group specific. – Napier grass is not the basal diet as most farmers use natural pastures.
2.	Sorghum (Serena & Seredo) Malindi Magarini & Marafa	 50 + 45 50 + 55 – + 68	– Rain fed. – Planting is by drilling 60cm between rows.	– Ensiling	– Few farmers plant the cereal.
3.	Improved Natural Pasture	100 Ha	Weeding, manuring and fencing	– Direct grazing, hay making.	– Plowing, manuring by few farmers.
	Un-improved natural pasture	6m Ha	Nil	– Communal, free range grazing. – Standing hay.	– Under utilized and not well managed.
4.	Maize: Malindi Magarini Marafa	 3,711 6,979 2,388	– Rain fed. – Use of certified and local seeds.	– Human feed. – 2% stalk used as livestock feed.	– Farmers release animals to harvested maize fields.

Table 26. Forage legumes and root crops in Malindi district (production, management and utilization)

1.	Leucaena	2.5 Ha	– Pure stand, alleys and hedge rows – Planting using direct seeds and seedlings	– Cut and carry – Direct feeding	– Hay making
2.	Gliricidia	0.25 Ha	– Pure stand, alleys and hedge rows-g – Planting using cuttings 1m x 1m	= do =	– Not palatable – Low adoption and recently introduced.
3.	Clitoria (blue pea)	1.20 Ha	– Planting by drill 1m between rows	– Cut and carry – Direct feeding	– Hay making – Drought resistant – Popular
4.	Mucuna	0.6 Ha	– Planting using seeds at 1m x 1m spacing	= do =	– Does well but affected by drought.
5.	Cassava	1.2 Ha	– Planting by cuttings at 1 x 1m spacing	– Leafy cuts and tubers used as livestock feed.	– Used by few farmers.

Napier grass is preferred but reliance is from natural pasture as is available or no cost involvement.25% for small scale farmers who initially plant and manage their Napier plots well but with time resorts to reliance on natural pasture and mismanaging their fodder.

3.6 Tana River District

A brief report on pasture and fodder development in Tana River District
John S. Masha, District Livestock Production Officer, Tana River District

Background and brief overview of Tana River District

Tana River District is the largest district in Coast Province with an area of 38,694 sq. km. The district has seven (7) administrative divisions (Galole, Bura, Wenje, Garsen, Madogo, Bangale and Kipini), 43 locations, and 93 sub-locations. Tana River District has an estimated human population of about 200,326 people, with 100,000 of them working in the livestock sector (source: C.B.S. 2002).

Tana River has an arable land area of 239 sq. km (1%), with rangeland occupying 27,048 sq. km (69%), national parks and forests 3,589 sq. km (9%), and others including lakes, rivers, and rocks occupying 7,818 sq. km (21%).
Government land occupies 30,877 sq. km (79.79%), Trust land 7,809 sq. km (20.18%), while free holdings are 8 sq. km (0.03%). The agroeclogical zones of Tana River are shown in Table 27 and Figure 9.

Table 27. Agroecological zones (AEZ) of Tana River District

	AEZs POTENTIAL	Altitude (m asl)	Enterprise
1	CL_3	3-10	Coconut – Cassava zone
2	CL_4	1-50	Cashew nut – Cassava zone
3	CL_5	1-60	lowland livestock, Millet zone
4	CL_6	20-100	lowland – Ranching zone

Figure 9. Agroecological zones of Tana River District.

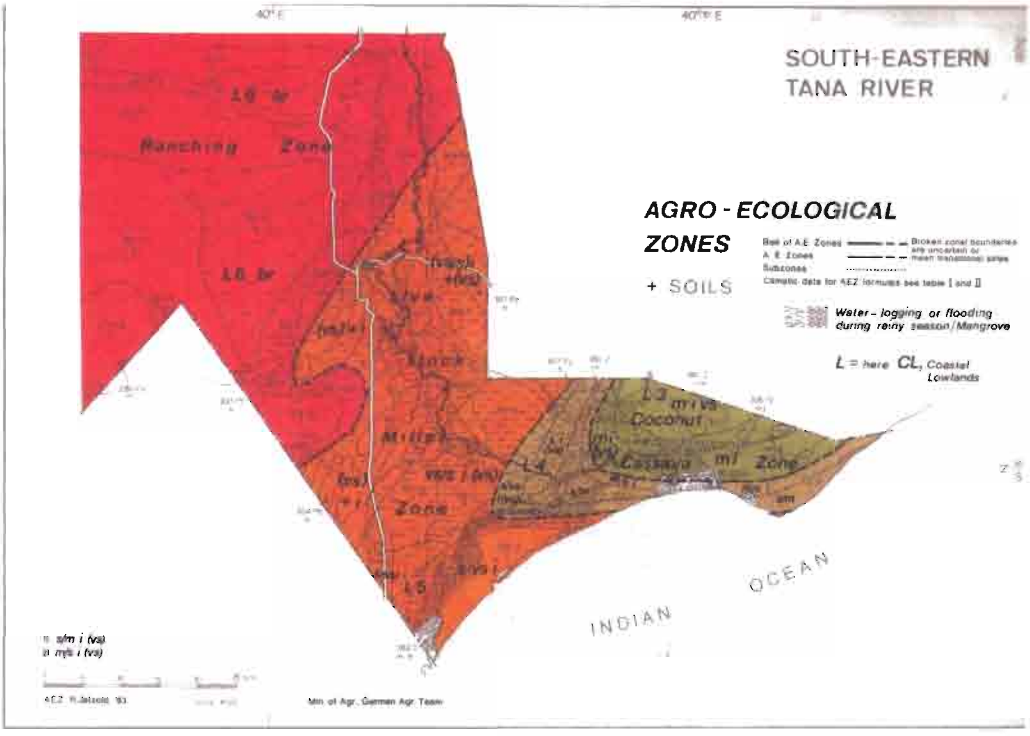


Figure 9. Agroecological zones of Tana River District.

For production purposes the district is divided into the following production zones the Coastal Zone, Tana Delta, Riverine, Hinterland, and the extreme Northern Zone. The Coastal Zone is a small area near the coast classified as Zone III (less than 5% of total land area). The Tana Delta is an area covering the lower Tana from Mnazini to Kipini. The Riverine Zone is a small stretch on either side of River Tana (east and west banks) with less than 2 km width in Galole, Wenje, and Bura divisions. The Hinterland is the area immediately after the Riverine and is the largest zone. The Extreme Northern Zone is more arid in Bura, Madogo and Banale Divisions.

Table 28. Livestock production in Tana River District

Type	Kipini	Garsen	Wenje	Galole	Bura	Madogo	Bangale	Total
Cattle	20,000	269,000	20,000	35,000	25,000	10,000	9,000	388,000
Goats	15,000	40,000	50,000	45,000	84,000	75,000	60,000	369,000
Sheep	10,000	35,000	40,000	40,000	70,500	45,000	40,000	280,500
Camels	-	-	-	-	8,500	20,000	30,000	58,500
Donkeys	10	640	1,000	1,350	5,500	5,200	6,000	19,700

Table 29. Maize production in Tana River District

	Targeted (Ha)		Achieved (ha)		Achieved production (Mt)	
Division	2002	2003	2002	2003	2002	2003
Kipini	300	300	236	354	212	496
Garsen	900	800	337	339	303	475
Galole	300	300	80	93	72	130
Wenje	160	120	118	68	106	95
Bura	250	350	11	655	10	917
Madogo	120	110	18	9	16	13
Total	2,030	1,980	800	1,518	719	2,125

Pastures and fodders in Tana River District

There are lush green pastures along the Riverine and Tana Delta, while standing hay is found in the Hinterlands. The main pastures and fodder species are *Chloris roxhiburghiana* (horse tail grass), which is a tufted and drought resistant grass found in almost all zones and preferable lands. *Cynodon spp* (star grass) is common in the wetlands in the Tana Delta and in the Riverine Zone. *Eragrostis superba* (Maasai love grass) is mostly found in the arid Northern Zone. *Sorghum spp are planted in* the Riverine and Tana Delta. Napier grass is grown by a few farmers in Coastal Zone at Kipini for feeding milk goats. Average area of napier per farmer is less than 0.25 acre in the Witu Settlement Scheme. Napier is also grown in the Bura Irrigation Settlement Project (BISP) on less than 0.5 acre for Sahiwal crosses under research.

Pastures continue to deteriorate as woody vegetation increases relative to herbaceous layers. There is increased bush encroachment in grazing lands while suppressing the useful or desirable grass species

Fodder production and pasture establishment are not common practices in Tana River District because of the following:

- Livestock production is mainly beef, i.e., the local zebu Boran or Orma boran, which are hardy and thus do well under local environmental conditions.
- Traditional systems of cattle rearing warrant movements of livestock between the Hinterland/north towards the Tana Delta during the dry and wet seasons.
- Some of the pastures are known to be notorious and hence become weedy, and such crops are not preferred by farmers.
- Land tenure system has discouraged pasture/fodder production.
- No research work or project on fodder has yet been done to encourage or support growth of fodder crops.

However, in April 2004, one acre of napier grass was to be established for the Gafuru Dairy and Beef Farmers Field School in Galole Division, but did not take off due to the prevailing drought situation

Tufted drought resistant varieties such as *Chloris roxhiburghiana, Sorghum spp,* napier grass may be socially and environmentally acceptable to our local farmers to integrate in their maize fields. The sweet potato vines are also desirable.

Recommendations

There is need for some interventions to support fodder production because of the following:-

- Pastoralists are becoming sedentary in the Tana Delta and around seasonal lagas like Wayu Boru areas and thus fodder/pasture programs may easily be adopted.
- There is some agro-pastoralism practiced, whereby some Riverine Zone farmers have started keeping livestock while some pastoralists have started farming practices.
- Processes of land adjudication and registration have started in the district and thus some pastoralists or farmers may take up land and start some fodder/pasture production.
- Increase in population and land development in the Riverine and Tana Delta Zones means farming, ranching, and irrigation projects may limit traditional livestock movement and thus increase the need for fodder production by livestock farmers.
- There is increase demand for dairy, i.e., milk goats (crosses) and sahiwal crosses. Some groups have taken up interest in starting projects, which require fodder/pasture development projects to supplement natural pastures.

4. Natural Pastures, Fodders and Grasses and their Distribution in Coastal Province

S.M. Njagi, Provincial Animal Production Officer (PAPO)

General Introduction

Out of the 17% arable land in Coast Province, only 3% is cultivated. This leaves 51,457 sq. km uncultivated.

Forage crops

Grasses and napier varieties include Rhodes grass (*Panicum maximum, French cameroon,* Clone 13, and Mott, and cereal crops (maize, rice, millet, sorghum, and sugarcane). Fodders include trees (*Leucaena spp* and Gliricidia), herbaceous legumes (clitoria, siratro, sweet potato vines, stylosanthes, *Dolichos lablab,* cowpea, mucuna, and centrosema (*Desmodium spp*).

The grasses found growing naturally in our natural pastures include H*yperrhenia spp, panicums, Digitaria spp, Cenchrus spp. (C. ciliaris, C. pennisetiformis), Chloris spp, Dactyloctenium spp, Cynodon spp, Eragostis spp, (E. ciliaris, E. cilisneusis), and Themeda spp.*

A compendium of important forage plants and grasses in Coast Province is necessary if not long overdue.

Table 30. Napier grass productivity climatic and forage parameters in Coast Province

Month / Year	Total Rainfall (mm)	Mean temp. (°C)	Av. Dry Matter content (%)	Total DM (t/ha)	Av. crude protein (%)	Av. acid detergent Lignin (%)
12/82	142.5	15.4	14.1	14.3	14.0	4.4
1/83	0.4	16.3	22.6	9.9	13.1	4.1
2/83	158.5	16.7	22.4	13.6	11.5	4.6
3/83	20.4	17.6	19.2	13.8	11.2	5.5
4/83	262.1	17.1	21.7	14.6	10.6	5.0
5/83	70.2	15.5	17.4	18.2	12.5	4.5
6/83	48.2	14.5	16.4	18.7	12.2	5.7
7/83	22.0	13.4	15.1	8.5	12.9	4.4
8/83	23.4	14.2	18.7	6.4	12.6	3.7
9/83	1.3	14.7	20.9	7.1	12.1	3.3
10/83	42.4	15.8	23.4	6.1	9.4	4.9
11/83	23.6	16.4	24.9	8.2	9.0	4.1
12/83	219.7	15.7	21.2	6.6	8.6	4.3
	1034.7			**146.0**		

Table 31. Natural pasture and arable land in each of the 7 districts of Coast Province

District	Total Area in Km	Arable Land	Range Land	Est. Natural Pastures
Kilifi	4,575	3,942	1,492	3,370
Malindi	7,605	1,148	5,700	3,150
Kwale	8,295	7,313	5,389	5,480
Lamu	6,814	5,517	2,061	5,110
Tana River	38,694	38,649	29,844	27,050
T/Taveta	16,956	5,824	4,080	3,874
Mombasa	282	90	-	84
Total	**83,221**	**62,483**	**48,566**	**48,118**

Table 32. Fodder crops area in the coastal districts of Kenya

District	Fodder type	Area (ha)	Estimated yield (t/ha)	Total production (tons)
Mombasa	Nat. Pastures	8,400	6.0	38,400
	Napier Grass	30	25.0	750
	Cereals stover	-	1.3	-
	Pulse threshings	-	1.5	
	Sweet P. Vines	-	5.0	
Kwale	Natural Pastures	548,000	4	2,192,000
	Napier Grass	600	25	15,000
	Maize Stover	-	-	5,000
	Millet	-	-	8
	Sorghum	-	-	10
	Rice	-	-	15
	Pulse threshings	-	-	120
Kilifi	Natural Pastures	337,000	3	1,011,000
	Napier grass	2,400	22	52,800
	Rhodes grass	3,600	10	36,000
Malindi	Natural Pastures	315,000	2	630,000
	Napier Grass	1,400	22	30,800
	Leucaena / Glyricidia	5	-	500
	Maize stover	7,600	1.0	7,600
Lamu	Nat. Pastures	511,050	1	511,050
	Napier Grass	500	20	10,000
	Fodder trees	20	3	60
	Maize stover	6000	15	90,000
	Sorghum	230	10	2,300
	Millet	48	9	432
	Pulse threshings	460	2	920
	Dolichos lablab	380	2	760
Tana River	Natural Pastures	2,705,000	1	2,705,000
	Maize Stover	762	-	160.05
	Millet	2	-	0.1
	Sorghum	9	-	0.54
	Rice	312.5	-	187.6
	Pulse threshings	180	-	5.62
	Banana Cuttings	148	-	1,419
	Sweet P. Vines	13	-	15.6
	Sugar cane tops	14	-	0.15
Taita - Taveta	Natural pastures	387,433	4	1,589,732
	Napier grass	1,064	22	23,408
	Maize stover	6,377	-	25,588
	Sorghum stover	162	-	648
	Millet stover	34	-	648
	S. Potato vines	152	-	608
	Pause threshings	3,431	-	14,984

Table 33. Percentage (%) of individual grass species dominance in the Coast Province

a) Hyperrhenia SPP	- 45%	- 21,653 Km^2
b) Cynodon SPP	- 15%	- 7,218 Km^2
c) Cenchrus SPP	- 12%	- 5,774 Km^2
d) Panicum SPP	- 10%	- 4,812 Km^2
e) Pennisetum SPP	- 7%	- 3,368 Km^2
f) Eragrostis SPP	- 5%	- 2,406 Km^2
g) Chloris SPP	- 3%	- 1,444 Km^2
h) Themeda SPP	- 2%	- 962 Km^2
i) Others i.e	- < 1%	- 481 Km^2
Silato	**100**	**- 48,118 KmKm^2**

5. Pasture and Fodder Utilization in Coastal Kenya

J.N. Kiura, Research Officer, KARI-Mtwapa

Introduction

Pastures and fodders are the main feeds that ruminant livestock depend on for maintenance and production. Livestock are important in coastal Kenya; cows feature most prominently in conversations but goats are a more realistic goal, whereas chicken are the daily reality (Waaijenberg, 1994). Over 90% of the farmers in the coastal region keep livestock (Kiura et al., 2003a). The cattle kept are mainly the zebu, but their crosses with the exotic dairy cattle are also kept for dairy production. About 20–28% of the homesteads in the sub-humid areas keep cattle (Swallow, 1996; Reynolds et al., 1993). The total cattle population for the Coast Province is 1,079,237 (Anon., 2001). Goats fit better in the densely populated areas (Waaijenberg, 1994); with the main breed being the Small East African goat. A few farmers keep the dairy goat breeds. The total goat population in the province is 1,022,007 while that of sheep is 466,307 (Anon., 2001).

Raising improved dairy cattle has been proved technically viable at the Coast Province (Swallow, 1996). Research on marketing and consumption of dairy products in the province indicated that there were commercial opportunities in dairying (Swallow, 1996). However, feed quantity and quality are the most limiting constraints to dairy cattle production in the region (Muinga et al., 1999). Variable feed availability contributes to the high cost of milk production (Swallow, 1996). Availability of suitable fodders and a feeding package are the first and second most limiting constraints for dairy and meat goat production, respectively, at the coast (Kiura et al., 2003b). It is therefore evident that availability and utilization of fodders affects livestock production in the Coast Province, in spite of the fact that cultivation of napier grass and leucaena trees as forages has proved agronomically sound (Swallow, 1996).

The use of napier grass requires that it be supplemented with a protein source, preferably under stall feeding, according to the National Dairy Development Project (NDDP) (Muinga, 1999). The commercial protein sources are expensive and alternatives such as forage crops are needed. Reynolds et al. (1993) observed that cultivated fodders by NDDP farmers constituted 15% compared to 78% for natural pastures as feed sources (the mean herd size was 2.6 cows, and land size of 5.6 ha per household). A case study in the Kaloleni area revealed that cattle were reared by herding (54.3% households), tethering (42.9% households), or stall feeding (2.9% households), and depended mainly on natural vegetation on fallowed land or crop residues (Swallow, 1996). In the wetter areas, Waaijenberg (1994) observed that some farmers were showing interest in zero grazing for dairy cattle, but even then the bottlenecks included provision of forage and water in the dry season. Therefore, few smallholder farmers have adopted the package of planting forages, and many farmers who once implemented the NDDP package were found not to have adhered to it in 1994 (Swallow, 1996). This calls for renewed efforts on fodder introduction and adoption.

Fodder availability to livestock at the coast is a major constraint in spite of availability of recommended fodders that are well adapted to the region. In addition, a large number of crops with potential for fodder were already being grown at the coast in the mid 19th Century. These included sorghum, maize, pearl millet, foxtail millet, lablab bean, sweet potato, and banana (Waaijenberg, 1994). During the *Kaya* period (1600-1850), sorghum was an annual staple crop along with finger millet and pearl millet, with sorghum being the most common (Waaijenberg, 1994). Maize (arrived in Mombasa in 1729) and rice replaced these cereals in the 19th Century (Waaijenberg, 1994). For the other food crops, cassava was important and by 1891, it was the staple food for the *Digo*, while they grew maize and sorghum as cash crops (Waaijenberg, 1994).

Available pastures/fodders used at the coast

The most abundant pastures/fodders fed to dairy cattle by farmers at the coast are natural pastures (a mixture of grasses and local legumes including trees and shrubs), napier grass, star grass, panicum and comellina (Muinga et al., 1999) in a decreasing order of availability. These came from farmers' own plots or neighbors' plots (Muinga et al., 1999; Swallow, 1996). These feeds require supplementation due to their low crude protein (CP) content (Muinga et al., 1999; Reynolds et al., 1993). Land acreage per household in the regions visited (Kilifi and Kwale Districts) ranged from 2-10 ha. A study (in Kilifi District) by Swallow (1996) revealed the composition of pastures and fodders used as feeds to be; natural pastures/vegetation (30.8%), crop and tree by-products and residues (31.8%), and planted fodders (22.7%). The forage constituents of each of these categories are shown in Table 34.

Most of the forages utilized as basal feeds have higher dry matter (DM) but lower CP than napier grass. Less of a high DM feed is required for animal satisfaction. The mean composition of the most abundant feeds (Muinga et al., 1999) is indicated in Table 35.

Natural pasture, which is mainly used, had less than 7% CP, below the limit for optimal rumen microbial activity (Muinga et al., 1999). Leucaena, gliricidia and herbaceous legumes have more than 20% CP and are appropriate supplements for the pastures (Muinga et al., 1999).

Table 34. Common, botanical and local names for the pastures and fodders used in Coast Province

Common name		Botanical name	Local name
Natural vegetation	(30.8%)	*Comellina benghalensis*	Dzadza
Wondering jew	(15.2%)	*Panicum maximum*	Maondo
Panicum	(6.4%)	*Cynodon dactylon*	Ukoka
Star grass	(5.3%)	*Cyperus rotundus*	Ndago
*	(1.8%)	*Asystasia gangetica*	Tsalakushe
*	(0.8%)	*	Masende
*	(0.7%)	*	Kitsangala
*	(0.3%)		
Crop and tree by-products and residues	(31.8%)		
Banana pseudo-stems	(2.9%)	*Musa spp.*	Mgomba
Cassava (leaves)	(0.8%)	*Manihot esculenta*	Muhogo
Mango (leaves)	(0.3%)	*Mangifera indica*	Muembe
Maize (husks)	(0.3%)	*Zea mays*	Mahindi
Cassava (peels)	(0.1%)	*Manihot esculenta*	Muhogo
Potato (peels)	(0.1%)	*Solanum tuberosum*	Viazi
Planted fodders	(22.7%)		
Napier	(14.9%)	*Pennisetum purpureum*	Gugu
Leucaena (leaves)	(6.7%)	*Leucaena leucocephala*	*
Gliricidia	(0.7%)	*Gliricidia sepium*	Hawesidi
Clitoria	(0.3%)	*Clitoria ternatea*	*

Source: adapted from Swallow (1996)
* - Name unknown or non-existent

Table 35. Chemical composition (%) of the most abundant fodders and pastures fed at Coast Province

Forage feed	DM	CP	NDF	ADL	Ash
Napier	19.6	7.1	69.4	5.4	12.7
Panicum	35.4	7.4	72.4	6.7	11.0
Natural pasture	41.0	6.4	74.0	6.9	9.1
Star grass	43.9	5.2	75.0	7.9	7.5
Comellina	25.4	10.2	55.3	9.4	16.3

Source: Muinga et al., 1999

Table 36. Feed chemical composition (%) and milk yield on use of 3 different legumes

Feed	DM	CP	NDF	Tannins	Milk yield (l/d)
Napier	20	07.6	69.0	1.27	4.0
Mucuna	22	18.0	59.6	0.30	5.3
Gliricidia	25	23.2	50.6	0.30	5.3
Clitoria	21	21.8	60.5	1.71	5.1
Maize bran	86.7	13.5	78.3	0.30	–

Source: Juma et al., 2004 (unpublished)

Using tree and herbaceous legumes as protein supplements to napier grass fed to lactating dairy cows, Juma et al. (2004, unpublished) demonstrated that the legumes led to increased milk production (Table 36).

Njuguna et al. (2004, unpublished) also observed that increased total dry matter intake increased (TDMI) on supplementing napier grass and maize stover with legume (mucuna, leucaena, gliricidia and clitoria). More napier (4.5 kg DM) was consumed than maize stover (2.7 kg DM) and total dry matter intake for cows fed on napier (8.5 kg DM) was more than for those fed on maize stover (6.7 kg DM), possibly due to lower neutral detergent fibre (NDF) in napier grass. High fiber increases retention time in reticulo-rumen reducing feed intake.

In goats fed on panicum hay supplemented with leucaena, gliricidia and Madras thorn (*Pithecellobium dulce*), legume supplementation increased TDMI and average daily gains (ADG) (Table 37) over a 7-week period (Kahindi et al., 2004, unpublished).

Table 37. TDMI and ADG in goats fed on different diets

Diet	TDMI (g)	ADG (g)
Panicum hay alone (+ maize bran)		
+ Gliricidia	229	01.6
+ Leucaena	387	18.7
+ Madras thorn	398	25.4

Source: Adapted from Kahindi et al. (2004, unpublished)

The chemical compositions of the individual feeds fed to the goats are shown in Table 38.

Table 38. Chemical composition (%) of feeds offered to goats

Feed	DM	CP	Tannins	Ash	EE
Panicum hay	85	04	-	3.20	02.15
Leucaena	25	25	4.39	6.87	13.25
Gliricidia	25	21	3.24	8.98	12.91
Madras thorn	25	23	1.94	9.92	12.45
Maize bran	90	15	-	3.00	09.69

Source: Kahindi et al., 2004 (unpublished)

Hay had CP (3%) below 7% minimum required for optimal microbial activity for maintenance (Kahindi et al., 2004). Protein supplementation from the legumes led to increased feed intake (Kahindi et al., 2004, unpublished).

From the foregoing, it is clear that high DM (over 20%), high CP (over 7% for grass, over 20% for legume), low crude fiber (NDF, ADL) and low tannin contents are important fodder utilization qualities.

Conclusion

There are well-adapted pastures and fodders in the Kenya coast region for use with livestock feeding that can serve as stem borer refugia (crops). Adapted food crops that can also be used both as fodder and as refugia exist, and the major effort required is toward making farmers see the need for their cultivation.

6. Review of Pasture/Fodder Research in the Coastal Lowlands of Kenya

Ali Ramadhan and N. Njunie, Research Officers KARI Mtwapa

Introduction

Coastal Kenya covers seven administrative districts: Lamu, Malindi, Kilifi, Mombasa, Kwale, Tana River and Taita/Taveta. The area under the review is mainly in the coastal lowlands. The rainfall is bimodal, with a long rainy season from April to June and short rainy season from November to December. The mean annual rainfall is 1,200 mm (Jaetzold and Schmidt, 1983). The soils are low in organic matter, nitrogen, and other essential nutrients. The area is inhabited mainly by mixed crop/livestock, smallholder farmers. Coconuts, cashew nuts, and citrus are major tree crops found in the area. Maize, cassava, and cowpeas are major food crops grown mainly for subsistence. About 60% of farmers own small ruminants, mainly goats, and 20% own cattle, mainly local zebu and dairy. Cattle are fed mostly on natural pastures (Muinga, et al., 1998). Some farmers feed cultivated forages using cut and carry system. The demand for milk in the region is 90,000,000 liters per year but only one-third of the requirement is met. One of the factors affecting milk production is availability of high quality feeds. In respect to this, KARI with ILRI, Government of Netherlands and IDA did research on pasture/fodder production in response to farmers' demand for increasing milk production in the region. Under review is the pasture and fodder production work that was conducted on-centre at KARI-Mtwapa and on-farm sites since 1980s.

6.1 On-station research

Pasture and fodder grasses evaluations

More than 140 grass entries were evaluated at Mtwapa and Mariakani research centers in the mid-1980s and 40 natural pasture and fodder grass species survived the climatic conditions of the areas. *Eragrostis superba* (Masai love grass), *Cenchrus ciliaris* (baffel grass), *Chloris gayana* var ex-tozi, *Setaria sphacelata,* and *Panicum maximum* (Guinea grass) were among the species that survived. Work done at Mariakani showed that *Clitoria ternatea* formed good grass/legume associations with *Chloris gayana* var. ex-tozi, *Cenchrus ciliaris* and *Panicum maximum* (Njunie and Ogora, 1992). The dry matter yields of pasture grass species varied from 2.3 to 3.8 t/ha. A study to characterize forages used for dairy cattle feeding was done in Kwale and Kilifi Districts. Results from 12 selected farms showed that farmers depended on locally available feedstuffs to feed their dairy cows. Most abundant feeds were: *Panicum maximum, Cyndon dactylon, Comellina benghalensis, Cyperus rotundus,* and *Asystacia gangetica.* Nine fodder grasses of napier var. Bana, Gold Coast, French Cameroon, Clone 13, ex-Machakos, mott, Ex-Kitale and Uganda hairless and local giant panicum were evaluated with the objective of determining forage DM yields obtained from three harvesting regimes (ILRI 1994). Harvesting every eight weeks gave 6 and 9% more forage DM yield than six or four weeks, respectively. Cumulative DM yields over 18 months ranged from 21.4 to 29.8 t/ha with giant panicum having the highest, followed by Clone 13 and Bana.

Fodder legumes evaluations

Sixty (60) accessions of herbaceous legumes obtained from the ILRI gene bank were evaluated in three contrasting sites (Mtwapa, Msabaha, and Mariakani) to determine seasonal growth patterns and forage yields within and between sites. Siratro and clitoria remained persistent and productive at Mtwapa (semi-humid) and Mariakani (semi-arid) zones (Njunie et al., 1994). Other promising legumes were *Glycine weightii,* Centro M. *Lathyroides spp* and *Stylosanthes scabra.* Two promising legumes, *Mucuna pruriense* and *Dolichos lablab,* were among the others that were evaluated at KARI-Mtwapa and on-farm at a later stage.

Fodder trees evaluation

Evaluation of 30 fodder trees of different species and accessions was done in June 1991 in order to determine forage DM yield and persistence to frequent harvesting for cut and carry system (ILRI, 1994). After a year of evaluation only 18 accessions had produced sufficient growth for harvesting. *Sesbania sesban* produced highest biomass (1.1 kg DM/tree) but the species failed to survive pruning during the year. Leucaena and gliricidia proved to be most productive fodder trees under frequent cutting management. Other species that were also productive were *Samanea saman, Calliandra callothyrsus* and *Albizia lebbeck*. Further evaluation of 23 gliricidia accessions showed that gliricidia accessions ILRI numbers 15483, 14986, 14501, 14502, 14503, 14504, 14506, and 14507 had yields equal or better than local accessions grown in the region.

Fodder and food production systems

The alley farming experiment utilizing leucaena hedgerows, combined with intercropped herbaceous legumes and application of slurry was conducted on-centre with the objective of offering solutions to the identified constraints to forage (napier grass and legumes) and food (maize) production in low fertility soils in the region. The leucaena hedgerows were planted 5 m apart, and napier grass or maize was planted between the hedgerows.

Napier/leucaena alleys

Results showed that presence of leucaena hedgerows did not significantly (P>0.01) reduce the yield of napier (Table 39). Slurry substantially increased napier yield while fertilizer applied at recommended rate further increased the napier yield.

Table 39. Fodder Dry Matter (DM) yield based on four harvests during the second cropping year

Leucaena hedgerow	Nitrogen sources	Napier	Leucaena	Clitoria	Total
Absent	-	9.8	-	-	9.8
Absent	-	9.6	2.5	-	12.1
Present	Clitoria	8.1	2.1	2.3	12.6
Present	Slurry	13.7	2.4	-	16.2
Absent	Fertilizer	15.6	-	-	15.6
	SED	1.25	0.10	-	1.3
	F test pob	**	*		**

NPK applied at 75kg N, 20kg P and 25 kg K (Potassium), Adapted from Mureithi et al., 1995.

By the end of third cropping year, slurry application increased soil organic matter (OM) by 21% and soil nitrogen by 33%, suggesting that slurry is likely to maintain soil OM level and nutrients. Clitoria treatment also increased soil nitrogen by 33%. Total yield achieved through combination of leucaena, clitoria and napier demonstrated increase in the supply quality of forages for dairy cattle.

Maize/leucaena alleys

Because napier and maize each compete for similar resources, an alley system experiment was planted using maize/cowpeas between leucaena hedgerows with the objective of studying the relative returns of using leucaena forage either as feed or as mulch on maize and applying slurry to napier and maize. Results showed that presence of leucaena hedgerows significantly reduced maize grain and stover yields, while cowpeas planted four weeks after planting, did not depress maize grain yield (Mureithi et al., 1994). However, presence of leucaena reduced weed growth between seasons. Full application of leucaena mulch (100%) increased maize grain yield by 44% over the sole maize. Application of slurry also increased maize grain and stover yield by 35% and 37%, respectively. However, maize grain yield in leucaena alley that was fertilized with slurry did not respond to more than 50% application of leucaena mulch, suggesting that half the leucaena forage could be used for feeding livestock. The yield increase in response to use of leucaena mulch compensated for labor required for hedgerow cutting and mulch application.

6.2 On-farm research

On-farm testing and adoption of forage production

Napier, clitoria, and leucaena were promoted on dairy farms in 1992 through field days where establishment and management practices of the fodders were demonstrated. Over 439 farmers expressed interest in growing the fodders. More than 288 farmers from four administrative districts (Kilifi, Kwale, Lamu and Taita Taveta) received seed and planted the legumes. Results showed that over 95% of the participating farmers recommended the same legumes to their neighbors (Njunie et al., 1994). About 60% adopted the agronomic and feeding practices recommended by research and extension.

Further on-farm evaluations were conducted in Kilifi and Kwale (Ali et al., 1997; Mwatate et al., 1997) where an additional promising 11 forage legumes (clitoria, centro, siratro, stylo, puero, calopo, dolichos, cowpea, mucuna, leucaena, and gliricidia) and eight fodder grasses (napier *var.* Bana, *ex*-Kitale, ex-Machakos, Uganda hairless, Gold Coast, French Cameroon, Mott and a local giant panicum grass) were tested under local climatic and farmer management conditions. Farmers chose clitoria, mucuna, dolichos, centro, siratro, leucaena and gliricidia as their best forage legume species. They chose them because of their good forage characteristics (such as drought tolerance, high DM yield, persistence to frequent cutting regimes, and high animal preference).

Introduction of napier varieties on-farm was done at a later stage during the phase of project implementation. At the time of evaluation, all grasses had established well. Earlier studies had been done to assess the benefits of these forages and factors affecting their adoption (Mureithi et al., 1995). The results showed that the cultivated forages contributed less than 40% and 25% of dairy cattle feeding during wet and dry season, respectively. Allocation of farm resources, availability of natural pastures, access of extension advice, availability of planting material, profitability of farming enterprises, and affordability of supplementary feed were other factors associated with adoption. Recent research done by the KARI/CIMMYT IRMA project at KARI-Mtwapa showed that various fodder grasses that were tested are also alternative hosts of stem borers and could be used as refugia in the management of insect resistance. It is, therefore, proposed that further work should look into the effects of cutting management and rates of fertilizer applications on the survival and dry matter yields of various potential refugia fodder crops.

◄ 7. Farmers Comment on Their Experiences with Growing and Utilization of Pastures and Fodders

7.1 Omari R. Mwamarifa, Farmer Matuga Patanani Farmer Group, Kwale District

Napier grass grows well on fertile and moist soils. I grow napier on clay soils. I have one acre of napier sown in rows to enable intercropping with food crops. I planted the cuttings during rain season and I found that most of them grew well. Initially I had a big problem in that the soil was not fertile. I later added manure after I got a cow and production increased. However, problems in napier come during the dry season when drought may be accompanied by leaf diseases. Termites also destroy napier roots. Weed control is also important for napier production. I prefer Bana grass as it resists drought stress.

The fodder tree leucaena grows well on my land, especially after I added manure. I can cut it repeatedly as it is an evergreen tree. I have planted it on separate plots, using 1m x 1m spacing.

Among pasture grasses, I have grown clitoria on a very small piece of land (4m x 1m). It has been planted on the rows of 1 ft x 1 ft and also needs wet soil. This is on experimental basis. I prefer the local type of pasture grass as it is adapted in my area. The natural grasses I grow are locally known as Futswe and Kungwe, which I have planted on half a hectare of my farm.

Among crops, I grow maize, cassava, and cow pea. I have grown maize on rows of 1 ft x 1 ft, usually dry planted. I store maize stover to feed my cows during the dry season. My preferred types are the local and hybrids.

In feeding livestock, napier, when used alone, gives good yield but has low feeding quality. Maize alone gives good yield but poorer than napier. When maize and napier are supplemented with leucaena, the yields increase two-fold as the quality is improved. Natural grass gives low yield except Mbondo, which approaches napier in forage yields. Futswe and Kungwe grasses reduce the milk butterfat, but give higher yields when supplemented with Napier.

7.2 Mohamed A. Bandari, Farmer, Kwale District

I grow crops, fodder, and pastures on a two acre farm. I have grown Bana grass on my farm. Bana grass does well if planted when there is enough rain, on fertile soils, and when planted in rows. Adding manure increases napier yields and persistence in the farm. However, I have observed root damage by insects and termites. Bana grass is my preferred type, as it is easier to harvest and can even do well with little rainfall.

Leuceana is among the trees that also do well when there are enough rains, and if grown on black cotton soil. I have planted leucaena along the boundaries, thereby allowing intercropping with food crops. Drought stress has been a problem. I also have gliricidia that is doing well. I lacked pasture grasses and I therefore have none, but have a small portion of natural pasture for emergency grazing. The grass in the surroundings has to be cut back to act as a fire break. The grasses in the natural pasture are mainly Dzadza, Futswe, and Mbondo.

I grow crops including cassava, maize, beans, and sweet potatoes. I have more cassava since it does well even with moderate rainfall—better than the other crops.

7.3 Ahmed Mohammed, Farmer, Lamu District

Lamu is divided into two zones. One division has ranches where we normally use giant panicum and some trees. The average size for the ranches is over 30,000 acres when we approach the rainy season; we burn the bush to prepare it for new grass. The new grass acts as medicine since it dehydrates the cow causing diarrhea, which cleans their stomach and as a result they become healthier.

At Mpeketoni, we use napier and hybrid maize for food and as fodder. The farming is small-scale, but we realize more milk than with natural pastures. The main problem we are facing is with the tree called Mkoma (Pulm Boom), as it harbors tsetse flies (Mbungo). We have tried many methods to control it, including fire, but all in vain. We are requesting KARI to help us control these trees.

7.4 Changawa Charo, farmer and official, Mkenge youth group, Mkenge sub-location, Gede, Malindi District

Table 40. Experiences of the group with 30 members on pasture and fodder grass production and utilization

Fodder crop type	Group acreage	Individual acreage	Agronomy	Utlization
Napier	$1^{1/2}$ acre	1 acre each	- Planting material was easy to get. Use Bana grass. - Planting 2 ft by 2 ft. - Planting using manure/DAP. - Using cuttings. - Harvest after 3 months. - Weeding after cutting. - Manuring and top dressing for good results. - No disease experiences. Experiences: - Adoption rate high.	- Cut then feed after chopping. - 4 sacks 20 kgs each. - Makes silage.
Gliricidia	20m x 50m	30m x 50m	- Planted using stem cutting - 2 ft x 3 ft spacing - Harvesting after 9 months	- Wilt for one day then feed. - Fresh from field not palatable.
Mucuna	30m x 50m	20m x 30m	- Planted using seeds - 2 ft x 3 ft spacing - Apply manure	- Feed leaves to cows after wilting.
Natural pasture	Communal Grazing area.	5 acre/Member	- Little attention	- Free grazing.

7.5 Serah Luwali, farmer and official, Bidii self-help group, Ganda, Malindi District

The group started in 1998 with an aim of poverty reduction among its members. The group started by growing vegetables having had plenty of water during the El Niño rains. Later they majored in dairy although the group was small. Initially, they got animals from KIND after having planted fodder crops.

(cont'd on page 3...)

Table 41. Experiences of the Bidii self help farmer group with 10 members on pasture and fodder grass production and utilization

Fodder crop types	Group acreage	Individual acreage	Date started	Agronomy	Utilization
Napier Grass	3 Acres	Members have two acres, 3/4 acres, 1/2 acre and 1/4 acres.	2000	- They started on small areas then increased. - Established using 3 node cuttings. - Spacing 60 cm x 90 cm (2ft x 3ft). - Harvesting at 3ft high to avoid stem ness. Experiences: - Napier does well on fertile soil with good moisture. - Direct grazing is harmful to Napier. - Napier is cut 1ft above the ground during drought to control termites. - Proper manure application, weeding and inter planting reduce the effect of drought. - No pests and diseases have been experienced - Palatability increases with wilting.	- After planting chop. - Wilting is essential during the wet season. Conservation: - Excess is used to make silage using molasses or bran. - Currently have more hence selling to neighbors and provides planting materials.
Leucaena	Plant population enough for one acre.	1/5, 1/4 acre plots	2001	- Planting space 2ft for each plant in a hedge row-boundary and inter planted with Napier. - First harvesting after 1 year. - Harvesting 4 times in a year. - No problem experiences up to now.	- Feeding to the cattle at 15Kg/day per cow to avoid bloat. Conservation: - Make hay (i.e. dry the leaves then feed with bran 1:1)
Gliricidia	Plant population enough for a 1/2 acre.	1/8 acre Few members have planted.	2002	- Planted using cutting. - Establishment during rainy season. - Harvested after 1 year. - Cutting pressure reduced by good management.	- Feed with leucaena and Napier.
Clitoria Mucuna	Plot 40m x 20m plots.	40m x 20m	2002	- Clitoria established by drilling. - Inter planted with Napier. - Mucuna is good for controlling nut grass.	- Feed a litte together with Napier and leucaena. - Feeding after 3 months.
Cassava Sorghum	Not significant				
Natural pasture	No acreage under pastures.	1 acres and above/member.	1998	- Natural grazing. - Very little attention needed.	- Intends to make silage.
Livestock	2 animals	2 animals		- Have lost some animals.	

Napier is preferred because it is plentiful and easy to meet the animal demand.

7.6 Emmanuel Yaa, farmer and official, Tumaini FFS, Bofa, Kilifi District

Tumaini is a dairy-oriented farmer's field school that was assisted by ATIRI through KARI-Mtwapa. We are upgrading dairy through an improved Brown Swiss embryo transfer bull. We have observed some fodders and legumes that could be sustainable in our area such as gliricidia, leucaena, cassava, napier, sorghum, clitoria, gretzo, mucuna, and sweet potato. Of all these, we found those suitable for our area as gliricidia, leucaena, and clitoria.

The natural pasture grasses found in our area are Masende, Katoja, Mwamba nyama and Dzadza, with Dzadza being the most resistant to drought.

Sorghum proved to be low yielding, with little vegetation for animal feed and the grain is a major attraction to birds. Living on settlement schemes limits agricultural land due to the enlarging families who have opted for intercropping of human food, like maize and cowpeas or maize and green grams. We are bulking the livestock feeds from 0.5 acres. We are also bulking cassava for food and feed. Drought has also taught us during the dry season that livestock can eat vegetation that is normally not eaten during the rainy season, e.g., Mairikita and onkade.

8. Field Visit to Two Livestock Farmers Near KARI-Mtwapa

Mr. A. Ramadhan and Mr. S. Bimbuzi, Researchers, KARI-Mtwapa

Two farms were visited by 32 workshop participants. The first farm visited belonged to the late Mr.Katana Masha, a renowned dairy smallholder farmer in the region. His son, Mr. Donald K. Mweni, is currently taking care of the farm, which is situated at Bomani location, Kikambala Division, Kilifi District. The farm is 12 acres, of which 10 acres were under fodder production. The fodder crops established were napier grass variety Bana grown within leucaena alleys. Leucaena alleys were established along with coconut trees spaced 10 m apart. There were also some gliricidia trees grown in the napier grass stand. Mr. Mweni said the fodder situation on the farm was not as good as it used to be because of the severe drought that had prevailed during the season. The napier grass was old (more than seven years) and some portion needed gapping. He had 20 cross-bred dairy cows, which were kept under zero grazing unit. Although there was a shortage of fodder, the animals looked attractive. Cows were fed on natural pasture obtained from the neighboring farms and supplemented with maize bran. The milking cows were at late lactation stage and were producing an average of slightly less than eight liters per day per cow. Mr. Mweni also showed farmers the other portion of the farm, which was planted with maize intercropped with cowpeas and green grams.

The second farm belonged to Mr. Mbesya. It is situated at Mtomomdoni location, Kikambala Division, Kilifi District. He was represented by his farm manager who welcomed the visitors to the farm. The farmer has two acres of which one was planted with napier grass. The napier grass looked healthy as it received a lot of manure from the zero grazing unit. The napier grass demonstrated itself clearly as a refugia species as farmers were able to observe stalk borer eggs, larvae, pupae, and exit holes from napier grass cut stems. The farmer had eight milking cows that were in good condition. The cows produced an average of 14 liters a day per cow. Napier grass was the only fodder established in the farm. The napier established in the one acre plot was not sufficient to feed all the dairy cows in the zero grazing unit. However, the farm manager convinced the farmers that he was able to maintain the cows by complementing the feed with poultry waste. During the visit, farmers were able to see the recommended agronomic practices for napier production and potential for using napier and natural pastures such as giant panicum and others as animal feed for increased milk production and as refugia. They also learnt that well managed napier is able to survive drought and can be cut for several years.

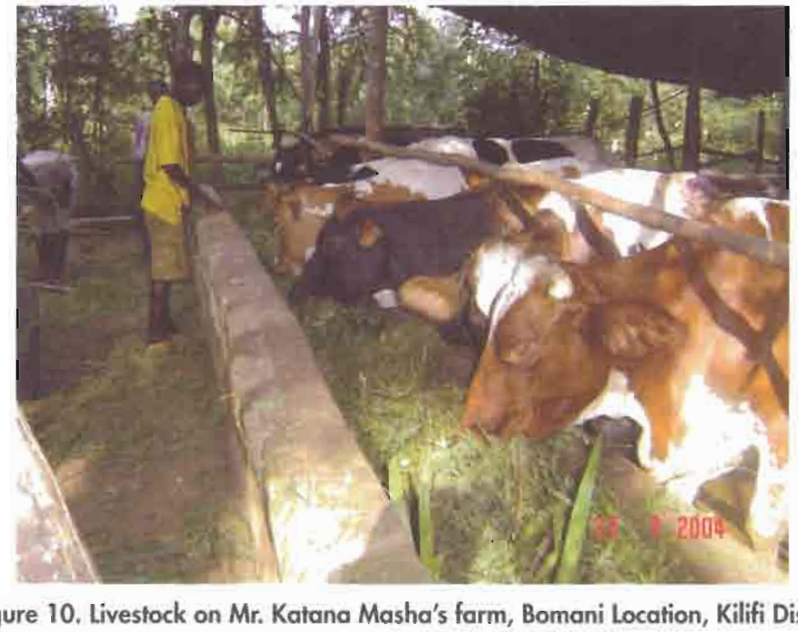


Figure 10. Livestock on Mr. Katana Masha's farm, Bomani Location, Kilifi District.

9. Practical Experiences with Refugia Species

9.1 Group exercise on ranking of refugia species in the experimental plot based on researcher, extension, farmer and individual criteria and assessing stem borer damage and other desirable characteristics

Dr. M. Mulaa

Participants were requested to separate into three groups: Group 1, farmers; Group 2 extension staff; and Group 3, researchers. Each group was requested to take one replicate of the refugia experimental plot set up by the IRMA project at KARI-Mtwapa, select 10 plants at random and record data on the number of stem borer damaged plants and number of stem borer exit holes. They were also requested to split the same plants and examine tunneling due to stem borers and record the number of stem borer larvae and pupae. Each group then ranked the crop species in each plot for suitability as pasture and as refugia using their own criteria. The groups then moved back to the workshop room for further data analysis and discussions on criteria for selecting crops for pastures and refugia. Each group selected representative to report during the plenary session.

Figure 11. Farmers examining tunneling and counting stem borer larvae and pupae.

Figure 12. Extension staff examining tunneling and counting stem borer larvae and pupae.

Figure 13. Farmers group data analysis and discussions.

Figure 14. Farmer representative presenting results during plenary session.

9.2 Group work, preparing information collected from the experimental plot for presentation in plenary. Group presentations (farmers, extension, researchers), synthesis, and general discussions

Table 42. Group 1: Data collected by farmers (Rank: 1 = Best, 5 = Worst)

Plot	Treat.	Plant species	Variety	Damaged plants	Exit holes /10 plants	Larvae/Pupae / 10 plants	Rank pasture	Rank refugia
No.	No.	Spp	Name	No.	No.	No.	(1-5)	(1-5)
1	5	Grass	Guatemala (K)	2	0	0	2	2
2	12	Maize	Mdzihana	28	5	1	1	1
3	30	Napier	16798	6	2	2	1	3
4	27	Local Sorghum	2 Brown	7	3	0	2	1
5	25	Napier	16837	5	2	2	1	1
6	1	Napier	French Cameroon	3	2	2	4	4
7	9	Grass	Giant Setaria	0	0	0	3	4
8	10	Napier	Bana	3	4	2	2	3
9	11	Local Sorghum	4 Brown	6	5	2	2	2
10	20	Napier	Ex-Matuga	6	1	0	3	3
11	26	Maize	Coast Composite	26	11	0	3	1
12	6	Napier	Kakamega 2	7	4	0	2	3
13	29	Grass	Sudan Grass	3	2	1	5	4
14	16	Local Sorghum	3 Red	17	3	6	3	1
15	24	Napier	Mariakani	8	4	1	1	3
16	21	Napier	Pakistan Hybrid	0	0	0	2	5
17	8	Napier	Clone 13	4	18	3	3	3
18	2	Maize	PH 1	10	0	0	3	3
19	19	Local Sorghum	9 Deep Red	0	0	0	5	5
20	13	Napier	Uganda Border	4	0	0	3	5
21	22	Millet	Pearl Millet	5	3	0	3	4
22	7	Grass	Giant Panicum	0	0	0	1	5
23	3	Napier	Kakamega 1	6	3	0	1	3
24	4	Local Sorghum	1 White	4	8	1	3	2
25	17	Grass	Columbus Grass	4	7	0	4	3
26	14	Maize	Pioneer	7	15	1	3	1
27	15	Napier	Kakamega 3	4	0	0	2	5
28	23	Maize	PH 4	11	4	1	3	3
29	18	Napier	Gold Coast	6	2	1	1	5
30	28	Napier	Motts	5	0	0	1	2

Table 43. Group 2: Data collected by extension staff (Rank: 1 = Best, 5 = Worst)

Plot	Treat.	Plant species	Variety	Damaged plants	Exit holes /10 plants	Larvae/Pupae / 10 plants	pasture	refugia
No.	No.	Spp	Name	No.	No.	No.	(1-5)	(1-5)
1	2	Maize	PH 1	12	0	0	2	4
2	1	Napier	French Cameroon	0	0	0	1	4
3	16	Local Sorghum	3 Red	17	25	9	3	2
4	13	Napier	Uganda Border	1	5	4	2	4
5	9	Grass	Giant Setaria	0	0	0	0	0
6	30	Napier	16798	0	1	2	2	4
7	14	Maize	Pioneer	5	2	4	4	2
8	18	Napier	Gold Coast	0	15	2	1	4
9	12	Maize	Mdzihana	9	31	1	2	4
10	5	Grass	Guatemala (K)	0	0	0	5	5
11	17	Grass	Columbus Grass	17	35	8	4	2
12	10	Napier	Bana	1	0	0	2	4
13	21	Napier	Pakistan Hybrid	0	0	0	1	5
14	24	Napier	Mariakani	3	6	2	1	5
15	4	Local Sorghum	1 White	0	5	2	4	2
16	25	Napier	16837	5	0	0	3	3
17	23	Maize	PH 4	5	22	7	1	5
18	22	Millet	Pearl Millet	9	0	0	2	4
19	6	Napier	Kakamega 2	3	0	0	1	4
20	7	Grass	Giant Panicum	0	0	0	2	4
21	20	Napier	Ex-Matuga	2	4	0	1	5
22	11	Local Sorghum	4 Brown	4	20	8	4	2
23	8	Napier	Clone 13	0	0	0	1	5
24	28	Napier	Motts	3	4	1	1	4
25	19	Local Sorghum	9 Deep Red	4	19	9	4	2
26	15	Napier	Kakamega 3	7	0	0	2	4
27	29	Grass	Sudan Grass	0	0	0	0	0
28	26	Maize	Coast composite	8	21	20	3	2
29	3	Napier	Kakamega 1	12	5	4	2	4
30	27	Local Sorghum	2 Brown	10	32	18	4	1

Table 44. Group 3: Data collected by researchers (Rank: 1 = Best, 5 = Worst)

Plot	Treat.	Plant species	Variety	Damaged plants	Exit holes /10 plants	Larvae/Pupae / 10 plants	pasture	refugia
No.	No.	Spp	Name	No.	No.	No.	(1-5)	(1-5)
1	3	Napier	Kakamega 1	2	0	0	1	5
2	19	Local Sorghum	9 Deep Red	9	8	4	4	1
3	15	Napier	Kakamega 3	2	1	1	3	5
4	9	Grass	Giant Setaria	1	0	0	5	5
5	8	Napier	Clone 13	1	0	0	2	5
6	22	Millet	Pearl Millet	7	7	15	4	1
7	28	Napier	Motts	0	0	0	0	0
8	29	Grass	Sudan Grass	6	3	4	5	3
9	25	Napier	16837	1	0	0	3	5
10	26	Maize	Coast Composite	54	50	8	3	2
11	18	Napier	Gold Coast	3	0	0	2	5
12	16	Local Sorghum	3 Red	0	1	0	4	4
13	2	Maize	PH 1	2	8	4	4	3
14	20	Napier	Ex-Matuga	1	5	0	2	5
15	10	Napier	Bana	5	0	0	4	5
16	27	Local Sorghum	2 Brown	8	17	5	5	3
17	14	Maize	Pioneer	9	21	8	3	2
18	24	Napier	Mariakani	3	0	0	2	5
19	5	Grass	Guatemala (K)	0	0	0	4	5
20	23	Maize	PH 4	30	11	2	2	3
21	7	Grass	Giant Panicum	0	0	0	5	5
22	30	Napier	16798	2	0	0	2	5
23	4	Local Sorghum	1 White	4	3	1	5	4
24	6	Napier	Kakamega 2	1	0	0	3	5
25	21	Napier	Pakistan Hybrid	1	10	0	2	5
26	13	Napier	Uganda Border	2	0	0	4	5
27	11	Local Sorghum	4 Brown	2	3	0	4	4
28	17	Grass	Columbus Grass	3	3	0	4	4
29	12	Maize	Mdzihana	4	15	4	3	4
30	1	Napier	French Cameroon	4	0	0	4	5

Table 45. Ranking of pastures and refugia by farmers, extensionists and researchers and criteria used for ranking

	Farmers	Extension	Research
		Best 5 for pasture species	
	Farmers	**Extension**	**Research**
1	Maize Mdzihana	Napier Ex Matuga	Napier Kakamega 1
2	Napier 16798	Napier Mariakani	Napier ex-Matuga
3	Napier 16837	Napier Clone 13	Napier ex-Mariakani
4	Napier Mariakani	Napier Kakamega	Napier 16798
5	Giant panicum	Napier Gold coast	Napier clone 13
		Criteria	
1	Vegetation	Level of infestation	Herbage yield
2	Drought tolerance	Plant establishment	Expert knowledge
3	Manure	Biomass	Leaf size
4	Readily available	Physical features (hairiness)	Plant vigor
5	Easy to handle	-	Establishment
6	-	-	Drought tolerance
		Best 5 for refugia	
1	Maize Mdzihana	Local Sorghum(9-Deep Red)	Local Sorghum (9 Deep Red)
2	Local Sorghum (2 Brown)	Local Sorghum (3-red)	Pearl Millet
3	Napier 16837	Local Sorghum (1-White)	Maize Pioneer
4	Maize pioneer	Local Sorghum(Brown)	Local Sorghum (2 Brown)
5	Napier Motts	Columbus Grass	Coast Composite Maize
		Criteria	
1	Resistance to borer attack	Level of Infestation (the higher the better)	Number of live pupae
2	Availability of seed	Ranked low as food crop and high as fodder	Number of exit holes
3	Used for pasture and Refugia (multiple use)	Tolerant to pest attack	Number of plants infested
4	Hay	Ability to attract and support stem borers	Leaf damage
5	Provides maize germ	-	Alternative uses

Table 46. Summary of selected species and selection criteria for pastures and for refugia

Selected pasture species

	Species	Number of groups selecting
1	Maize Mdzihana	1
2	Napier 16798	2
3	Napier 16837	1
4	Napier Mariakani	3
5	Giant panicum	1
6	Napier Ex-Matuga	2
7	Napier Clone 13	1
8	Napier Kakamega	2
9	Napier Gold coast	1

Criteria for selecting pasture species

	Criteria	Number of groups selecting
1	Herbage yield	3
2	Drought tolerance	2
3	Alternative uses - manure	1
4	Availability	1
5	Establishment/Handling	3
6	Physical features	2

Selected refugia species

	Species	Number of groups selecting
1	Maize Mdzihana	1
2	Napier 16837	1
3	Maize pioneer	2
4	Napier Motts	1
5	Local sorghum (deep red)	2
6	Local sorghum (3 Red)	1
7	Local sorghum (White)	1
8	Local sorghum (brown)	2
9	Columbus grass	1
10	Pearl millet	1
11	Coast composite maize	1

Criteria for selecting pasture species

	Criteria	Number of groups selecting
1	Resistance to stem borers	3
2	Availability of seed	1
3	Alternative uses	3
4	Ability to attract and support stem borers	3

10. Harmonizing Project, Researcher, Extension, and Farmer Performance Indicators

Mr. J. Ndungu, Socioeconomist, KARI-Mtwapa

What are "indicators?"

Indicators are pieces of information that help you to understand where you are, which way you are going, and how far you are from where you want to be. They are (a) qualitative and quantitative measures used to monitor progress made towards the achievement of expected results over time in a specific intervention compared to targets, and (b) markers, proxies for the real thing.

Uses of indicators

Indicators can be used

- as a means to track progress towards achievement of results;
- to measure achievements of results over time and compare targets;
- to detect whether you are failing or succeeding;
- to measure beneficiary or client satisfaction;
- to communicate results to stakeholders as:
  - quantitative statistical measures,
  - qualitative judgments or perceptions, and
  - scientific indicators and grassroots indicators;

Performance questions usually asked when dealing with indicators are

- What criteria do farmers use to evaluate different technologies?
- Are there differences between farmers in their preference of different technologies?
- What is the probability of adoption of different technologies?

Types of indicators

There are two main types of indicators: scientific and local indicators.

- Scientific indicators often contain quantitative information based on precise and replicable measurements. They are disciplinary, global and generic (e.g., disease scores, yield, incomes, etc.). Scientific indicators are important because they are used to understand and explain in a systematic manner the physical, social and economic phenomena and to test research hypotheses, to ascertain casual links between processes and results.
- Local indicators correspond to a language commonly used by farmers or community to describe the characteristics of a phenomenon by using words they understand easily. These are mainly used by local stakeholders and may vary from different groups and locations. They are based on the experiences, perceptions and knowledge of local people.

Qualitative vs. quantitative indicators

Qualitative indicators can be used to measure

- extent of satisfaction of beneficiaries;.
- perception of women about their participation in enterprise selection;
- coherence between the enterprises selected and resources of farmers; and
- level of distribution of benefits among members of the household.

Examples of quantitative indicators are (1) number of men and women with experiments, (2) herbage yield (quantity), (3) income (amount), (4) percentage of farmers adopting technologies, and (5) ratio of men and women in decision making positions in FFS. Indicators should be defined at all levels of the impact chain (PM&E framework).

Criteria for selecting indicators

Indicators should be valid, representative, reliable, simple, useful and affordable:

- Valid: Does it allow you to be precise in measuring or describing the results?
- Representative: Does it provide disaggregated information by sex, age, group location?
- Reliable: Is it a consistent measure of trends over time?
- Simple: Will it be easy to collect and analyze the information?
- Useful: Will it be useful for decision making, learning and sharing?
- Affordable: Can we afford to collect and analyze the information?

Properties of indicators

Indicators should be **SPICED** (Subjective, Participatory, Interpretable, Comparable, Empowering, and Diverse):

- **S**ubjective: self reflection of experiences
- **P**articipatory: involve farmers extension and researchers
- **I**nterpreted: easily explained to different groups
- **C**ross-checked or **C**omparable: triangulation
- **E**mpowering: reflect critically on own situation
- **D**iverse: indicators from different groups

Key questions in developing indicators

- What would tell us we have achieved our outputs, outcomes?
- What will show us we have successfully carried out our activities?
- What will show that men and women have achieved their expectations?
- What will show us we are achieving the processes?
- What will tell us we are failing to achieve the processes?
- What do we need to look at?

Harmonizing research, extension, and farmers indicators

- You need to know whose progress you are measuring (is it your own perception, researcher, extension or community perception?)
- Who defines development, the experts or people concerned? Participatory techniques can make identification of indicators a joint exercise.
- Know what has been done to avoid replication.
- One should never adopt indicators uncritically. They should be based on local people's judgment and not your own.
- Seek clarification when not sure of certain meanings, e.g., standard of living (caloric intake, wealth levels, health status, etc.)
- Farmers indicators are usually based on experiences and they may vary in different areas.

11. Developing Participatory Monitoring and Evaluation Frameworks

Mr. Danda Kengo, Socioeconomist, KARI-Mtwapa

Introduction

Monitoring and evaluation (M&E) is not a new concept, however, it has generally been done on a spot basis and by special task groups thereby making it appear to be used for investigating and "policing" (time and resource auditing) projects. There is a need to demystify M&E. Introduction of the participatory (P) aspect was thought to be instrumental towards collective ownership of M&E activities across all stakeholders. Research projects need to have clear frameworks for monitoring the changes that have taken place as a result of the project. Researchers, extensionists, and farmers need feedback on what is not going well, so that adjustments can be made. Communities are interested in change (e.g., increasing their income levels) and also monitoring how that occurs, but they are not involved. The advantages of participatory monitoring and evaluation are that the stakeholders are involved in planning, implementing, tracking progress, and reviewing projects. It also allows for joint decision-making to ensure sustainability and partnership.

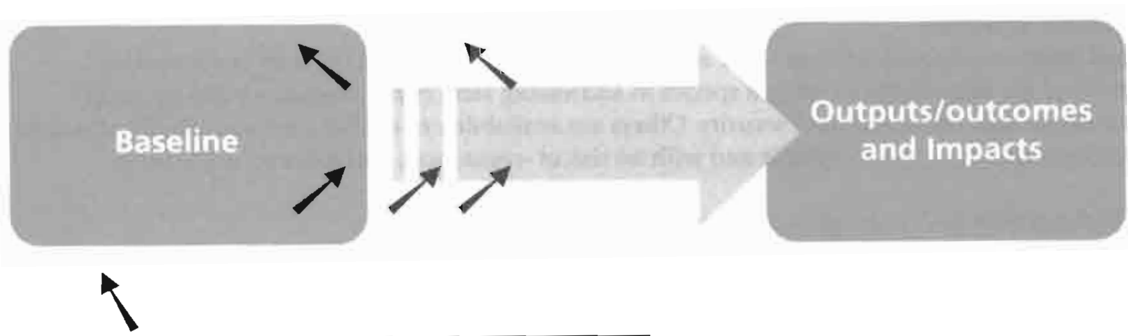
Critical steps followed or key questions asked when conducting PM&E·

What is our impact goal?

- Where are we now?
- Where do we want to go?
- How do we get to the desired situation?
- What will make us succeed or fail
- How shall we know that we are succeeding?

Current Situation:
Where are we now?

Desired Situation:
Where do we want to be?

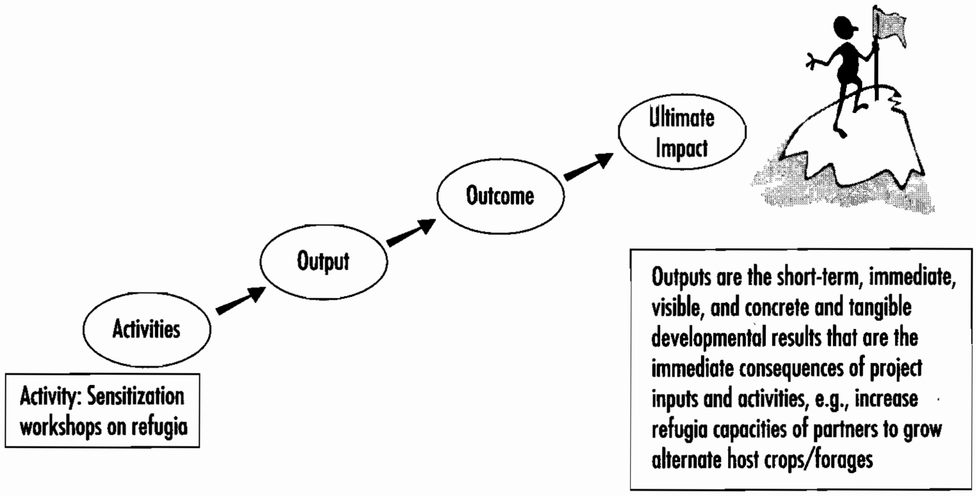


- *What changes do we expect?*
- *What do we need to do to achieve our objectives?*
- *What can make us succeed or fail?*
- *How do we know that we are making progress or not?*
- *What will tell us?*

The impact chain

Monitoring and evaluation frameworks are systems of reporting outputs and outcomes. They explain the link between project activities, outputs, outcomes, and impacts. Impacts are long-term, at the developmental level and linked to the goal or vision. They are combinations of outputs and outcomes, but they are not the direct results of a single project or program, e.g., improved livelihoods, poverty eradication.

Outcomes are medium term, end of project developmental results benefiting an identified target population that is achievable within the time frame of the project, e.g., increased refugia acreage, milk yields, incomes, crop diversification.



Impact goal for IRM

Prevent build-up of resistance by stem-borers by use of refugia species with economic value and socially acceptable in Kenyan farming systems.

Our current situation

High yield losses caused by stem-borer, high costs of controlling stem borer, food insecurity due to losses and poor harvests, and lack of or little crop diversification. Others are low refugia acreage, lack of information on need for refugia at farm level, lack of animal feeds, risk of pest resistance to Bt-maize, and high risk and prevalence of soil erosion.

The desired situation

Reduced losses, availability of stem borer resistant varieties, reduced costs of stem borer control, awareness of the importance of refugia species in addressing stem borer resistance build-up, crop diversification, and enhanced food security. Others are availability of animal feed, availability of suitable refugia (socioeconomically acceptable and with no risk of -resistance), and reduced soil erosion.

Expected outputs (1-2 years post-intervention)

Farmers awareness about the importance of refugia species in management of stem borer resistance to Bt-maize, management of stem borer resistance to Bt-maize by use of refugia, and increased fodder quantity / quality following the introduction of refugia. Others are reduced soil erosion and increased range of crop species in farms.

Expected outcomes (2-3 years later)

High maize yields, improved / enhanced food security, better livelihoods, improved livestock health, and increased milk yields. Others are increased incomes to farm households and prolonged effectiveness / usefulness of Bt-maize.

IRM project objectives

- Sensitize farmers, extensionists, and researchers on importance of refugia in the management of insect resistance.
- Map percent natural and cultivated refugia species at district level and identify regions without enough refugia.
- Identify potential refugia species to be tested for stem borer and other insect resistance management strategies on-station and on-farm based on experiences from farmers, researchers, and extensionists.
- Characterize stem borer host suitability as refugia using field trials and lab bioassays. Integrate pastures, fodders, and cereal crops as stem borer refugia in the existing farming systems.

Processes/activities that will make us meet the IRM objectives/goal

On-station and on-farm trials, capacity building through training, and monitoring and evaluation.

What will lead us to success?
Creating awareness about refugia importance (sensitize stakeholders), lists of effective refugia based on data from literature and trials, farmers willingness to participate, multidisciplinary team approach, and identification of refugia that fit the existing farming system.

What could make us fail?
Misunderstanding about the use of refugia, unavailability of suitable refugia in the region, and selection of refugia with no economic and social value.
What will show that we are succeeding? (establish indicators)
Quantitative (increased milk yields, incomes, etc.) and qualitative (improved livelihoods, etc.) indicators.
Things to remember At every stage and some key questions that should be asked:
- What had we planned to do?
- Which tools/methods shall we use to collect the data?
- What went on well?
- What did not go well?
- What shall we do to improve on our outputs/ outcomes/processes?

Note: Constant reflection and answering of these questions will make PM&E in-built in our activities and it will serve as a continuous process.

12. General Discussions (Question and Answer Session)

Question by Mr. Mwamarifa:	How will you make Bt maize seed available to the farmers?
Response by Dr. Mugo:	The seed will be available but not necessarily cheap. It will come to the farmers mainly through the usual seed companies.
Question by Mr. Kimani:	Why are staff in greenhouses dressed in red coats?
Response by Dr. Mugo:	Regulatory bodies develop rules for handling. There are several levels of biosafety. Bt maize has been placed on Biosafety Level 2. Level 2 means there is no known harmful effects to humans or environment. The red color of the coat is to ensure that one does not take it away from the greenhouse. It is not an indication of danger in any way.
Question by Mr. Morowa:	What is the position of the government on genetically modified organisms (GMOs)?
Response by Mr. Kimani:	The ministry has accepted GM, so long as they are used for a worthy cause.
Question by Mr. Abdillahi:	The protocol used for production of Bt maize was developed in other countries. Give us the experience in those other countries.
Response by Dr. Mugo:	Bt maize is now grown on 70 million ha worldwide. The largest acreage is in the USA, China, Argentina, and South Africa.
Question by Mr. Abdillahi:	There has been fear of new technologies right from the introduction of hybrid maize. There is fear of consuming Bt maize.
Response by Dr. Mugo:	Bt maize has been consumed in the USA since 1996 without negative effects. There is no fear as the consumers will be enlightened and educated to be comfortable with the technology.
Question by Mr. Mukuna:	Farmers indicated that by planting napier around maize plots, this reduces stem borer infestation on maize. Please comment.
Response by Dr. Mulaa:	Napier has been proved to control stem borer when used in thepush-pull technology manner (a technology developed by KARI ICIPE scientists). It has been a adopted by many farmers in western Kenya where it has been tested and proven to be effective.
Suggestion by Mr. Jefa:	Could the population in refugia be reduced by sterilization?
Response by Dr. Mulaa:	We do not want to interfere with a natural system, and as we have explained in this workshop, the susceptible stem borer populations can be used to manage insect resistance.
Question by Mr. Abdillahi:	A lot of emphasis is on napier but areas like the coastal lowlands do not have napier. Will other grasses in this area be good natural refugia?
Response by Dr. Mulaa:	Yes, grasses like giant panicum and Columbus grass will be useful.

Observation by Mr. Kangunu:	Napier is a good refugia, but farmers cut it very early, and this may not allow the stem borer to emerge.
Response by Dr. Mulaa:	This is only applicable if all the napier in the field is all cut at once. But if it takes 60 days for stem borer moths to emerge, then cutting frequently should be harmonized so that napier is available throughout the year.
Question by Mr. Morowa:	When does refugia cease to be refugia in terms of distance from the maize crops or the most suitable area (size) of refugia required to bring desired population of the stem borer?
Response by Dr. Mulaa:	This has not been well studied. However, it is recommended to have the refugia as close as possible to the maize crop
Suggestion by Mr. Kangunu:	Ensure napier is always available—forage parts available and not everything cut down.
Suggestion by Mr. Jefa:	Need to factor economic data into our research, in view of the fact that economic considerations will be considered as we commercialize agriculture.

Questions and answers during farmer field visit

Question by Mr. Kiruiro	How do you rate maize vis-à-vis dairy enterprise?
Response by dairy farmer:	Maize as a choice of enterprise on my farm is lowly rated, dairy is better.
Question to farmer:	Then why have you put such a large area under maize, yet say it is less important?
Response by farmer:	You know your question borders on domestic politics. I have to meet the social needs of the other family members who need maize more than anything else.
Question to farmer:	Why does your maize look miserable yet you have lots of manure from the zero-grazing? Don't you apportion some to the maize?
Response by farmer:	Normally I use inorganic fertilizers for the maize: planting and topdressing. I put a "bit" of it, but this season the weather has not been favorable. However, for manure application, preference is given to napier grass as far as my farm is concerned.

13. Closing Session

Mr. Mohammed, farmer representative

Mr. Muhammed thanked CIMMYT and KARI for a well organized and successful workshop. He cited the following experiences and lessons: a friendly working environment, very educative time as farmers were now more enlightened on biotechnology, Bt maize technology and pastures fodders as refugia to go along with Bt maize technology. Mr. Muhammed lamented that if more can be done to expose farmers to new methods, then the farming community can revamp agriculture to fight poverty. The workshop has given hope to farmers that there are opportunities to expand on production. There are great opportunities to seize from KARI on other technologies to help farmers. He requested Mr. Muli to forward the documents mentioned during the workshop, and others on various technologies from KARI to participants for their use.

Mr. Masha, extension staff representative

Mr. Masha commended the workshop organizers for ensuring that it was participatory, involving researchers, extension staff, and the farmers. The workshop opened up new areas of thought/experiences that could be useful in developing technologies to assist farmers improve agricultural production, thus keeping them out of hunger. Farmer involvement is commendable since it will afford feedback that can be considered when developing and/or packaging the technology. In the past, low involvement of farmers has resulted in poor adoption of technologies.

Dr. Mwamachi for Center Director-Mtwapa

Dr. Mwamachi said he was grateful to the organizers to have involved KARI, especially at the forefront in the study of IRMA strategies, considering that there are a lot more challenges at the coastal region. The Centre as a whole will take the responsibility in disseminating the technologies, once they are fully developed. The workshop lived up to its expectations and it has achieved a lot. Farmers should be empowered with skills of data collection and analysis by all projects. He thanked all participants and said that any interested parties should feel free to visit KARI-Mtwapa, where they can learn more.

Official Closing Speech by Mr. S. Abdillahi, Provincial Director-Livestock Production, Coast Province

Ladies and gentlemen, it gives me great pleasure and honor to officially close this unique and yet very successful workshop, which has been ongoing for the last couple of days, drawing participants from KARI, CIMMYT, MoA extension providers, and the crop/livestock farmers in the Coast Province. This workshop is a milestone in the agenda towards ensuring food security in the region that is a food deficit zone, by a record of two million bags of maize.

The disclosure of a large deficit of maize leading to constant hunger among our people is a very disturbing fact that warrants urgent intervention measures from all who can. As usual, it is highly expected that researchers in close collaboration with extension staff and farmers will lead the way.

The concept of integrating pastures, fodders, and cereal crops as refugia for stem borers in the Kenyan farming system is a welcome and noble development that is likely to contribute toward closing the gap between the potential of maize production against the actual production in the province. An important observation that requires urgent attention is the familiar scenario whereby maize yields on-station are substantially higher than those on-farm. It is a question of partial adoption of recommended technologies due to factors inherent with the farmers that requires thorough investigation. This is a challenge not only to the researchers, but to all those who participated in this workshop.

Chemical control of the stem borer has been a self defeating attempt by the farmer as the insect has over the years caused great losses to the already meager maize yield from the small holding of the coast farmers. This is due to the low purchasing power of the coast farmers compared with farmers elsewhere in the country. The presentations by the participants show that there exist cereals crops fodder and pasture species that can act as refugia to the devastating stem borer pest. This in itself is a reflection of the general need to find a lasting solution to this food deficit while at the same time ensuring environmental and economical friendliness in a sustainable manner. In order for this concept to score highly and generate enthusiasm, especially in the farming communities that are critical stakeholders in the overall success of the project, it may be prudent to involve a greater number of both farmers and extension staff, especially those at the frontline or divisional level. To this end, some modest funding could be provided to carryout quick sensitization seminars/workshops, lasting a day or so, in each district.

There are many ways of getting started towards realization of the integration of pastures, fodders, and cereal crops as refugia for stem borer. Nevertheless, the FFS methodology of extension, which is enjoying widespread acceptance by our farmers, can be a good entry point for this concept whose multiplier effect can prove very encouraging within a short timeframe.

Our main business, obviously, as researchers and extension providers is to ensure that there is enough food for consumption at household level through whatever means possible. We give thanks to the researchers who have so tirelessly researched into all possible refugia for the stem borer with a view to increasing food production. This is the only way we can be relevant, otherwise our roles as government officers would become insignificant. The active participation of the farmers throughout the workshop period is an indication of how good ambassadors they shall be when they report back to their farms to continue with their farming activities to feed this province.

Last but not least, I wish to pay glowing tribute to the Syngenta Foundation for Sustainable Agriculture for providing the funding for this workshop, which has proven a resounding success.

We have all enjoyed listening to the presentations and have learned a lot.

Let's continue with this research/extension/farmer networking to alleviate hunger in the province by planting enough refugia to eliminate the notorious stem borer within our maize fields!

It is now my greatest pleasure to declare this workshop officially closed.

VOTE OF THANKS by Dr. S. Mugo

Dr. Mugo thanked the Center Director, KARI-Mtwapa for hosting the workshop and for availing many resources, including her scientific and support staff for various activities. He also thanked the PDA Coast Province, together with all the extension staff from the provincial office and from the district offices, for their effective participation in presentations and fruitful discussions.

Dr. Mugo gave special recognition to Mr. Benjamin Muli and the other members of the KARI-Mtwapa team, especially Mr. Ali Ramadhan, for various arrangements. He cited Dr. Margaret Mulaa as the scientist behind the workshop and noted that she did a lot to plan and organize the course.

He gave special thanks to the farmers who left their homes and fields to come and share their experiences with researchers and extension.

The various presenters, session chairs and rapporteurs, and cafeteria staff, and drivers were also recognized.

Dr. Mugo wished all participants safe trip back home.

References

Anon (Anonymous). 2001. *Annual Report*, Coast Province, Ministry of Agriculture and Rural Development, Kenya.

Ministry of Agriculture - *Coast Province Annual Reports 2000-2003.*

De Groote H. 2002. Maize yield losses from stem borers in Kenya. *Insect Science and Its Application.* 22(2):89-96.

Georgiou G.P. 1990. Resistance potential to bio- pesticides and consideration of counter measures. In: J. E. Casida (Ed.) *Pesticides and Alternatives*. New York: Elsevier. Pp. 409-420.

Gill S.S., E.A. Cowles, and F.V. Pietrantonio. 1992. The mode of action of *Bacillus thuringiensis* endotoxins. *Annu. Rev. Entomol.* 37: 615-636.

ILRI. 1994. *Feed resources for smallholder dairy production in coastal sub-humid Kenya* Addis Ababa Ethiopia: ILRI. Pp.147.

Jaetzold R., and H. Schmidt. *Farm Management Handbook of Kenya.* Nairobi: Ministry of Agriculture and GTZ. Nairobi. Pp. 411.

James, C. 2003. *Global Status of Commercialized Transgenic Crops*: 2003ISAAA Briefs No. 30. Ithaca, NY: ISAAA.

Juma, H.K., S.A. Abdulrazak, R.W. Muinga, and M.K. Ambula. 2004 (Unpublished). Evaluation of clitoria, gliricidia and mucuna as protein supplements to napier grass basal diet in relation to the performance of lactating Jersey cows.

Kahindi, R.K., S.A. Abdulrazak, and R.W. Muinga. 2004. (Unpublished). Utilisation of Madras thorn, leucaena and gliricidia as protein supplements for growing goats in the coastal lowlands of Kenya.

Khan, Z. R., P. Chiliswa, K. Ampong-Nyarko, L.E. Smart, A. Polaszek, J. Wandera, and M.A. Mulaa. 1997. Utilization of wild Gramineous plants for management of cereal stem borers in Africa. *Insect Sci. Applic.* (17) (1): 143-150.

Kiura, J.N., C.K. Mutegi, M.K. Danda, and P. Kibet. 2003a. Cassava Production, Utilization and Marketing in Coastal Kenya. A paper presented at a Research/Extension Seminar on 12th November 2003, KARI-Mtwapa.

Kiura, J.N., D.M. Mwamachi, and K. Danda. 2003b. Goat Production Systems in Coastal Kenya. A paper presented at the First Adaptive Research Conference, 16-19 June 2003, KARI Headquarters, Nairobi, Kenya.

Mallet J., and P. Porter. 1992. Preventing insect adaptation to insect resistant crops: are seed mixtures or refugia the best strategy? *Proc. R. soc. London Ser.* B 250: 165-169.

Mc Gaughney W., and M.E. Whalon. 1992. Managing insect resistance to *Bacillus thuringiensis* toxins. *Science* 258: 1451-55.

Muinga, R.W., S. Bimbuzi, and L.C. Mambo. 1999. Nutrient composition of locally available feedstuffs in coastal lowland Kenya. In: *Kenya Agricultural Research Institute. Proceedings of the 6th Biennial KARI Scientific Conference,* Nairobi, Kenya, 8-13 November 1998. Pp.287-293.

Mulaa, M. A., C. Chesoli, P. Kalama, and A. Mugita. 1999. Increasing farmers options for stalk borer control. A comparison between efficacy of natural products and artificial pesticides. *Proceedings of KARI/DFID NARP II* end of project conference. Pp.254-256.

Mureithi, J.G., R.S. Taylor, and W. Thorpe. 1994. Effects of alley cropping with *Leucaena* and different management practices on productivity of maize and soil chemical properties in lowland coastal Kenya. *Agroforestry Systems. 27:31-51*

Mureithi, JG., R.S. Taylor, and W. Thorpe. 1995. Productivity of alley farming with Leucaena (*Leucaena leucocephala* Lam. de Wit) and napier grass (*Pennisetum purpureum* K. Schum) in coastal lowland Kenya) 31*:59-78.*

Mureithi, J.G., M.N. Njunie, A.R. Ali, R.W. Muinga, W. Thorpe, and C.D. Mwatate. 1997. Factors affecting adoption of planted forages in coastal lowland Kenya. Paper presented at the American Society of Agronomy Conference (ASA), California, USA. 26th-31st October, 1997.

National Academy of Sciences, 2000. Transgenic plants and world agriculture. http://www.nap.edu/html/transgenic

Njuguna, P.M., R.W. Muinga, and M.H. Saha. 2004 (Unpublished). Evaluation of manure from cows fed on napier grass or maize stover basal diet supplemented with gliricidia, clitoria or mucuna.

Njunie M.N., J.G. Mureithi, A.R. Ali, R.W. Muinga, W. Thorpe, and A.N. Chibudu. 1994. Development and transfer of forage production technologies for smallholder dairying: Experiences on farm trials with legumes in coastal lowland Kenya. In: *Proceedings of the 4th* KARI *Scientific Conference held at Silver Springs Hotel,* 25-28th *October 1994, Nairobi, Kenya.32-45.*

Njunie, M.N., and R.B. Ogora 1992. Evaluation of forage of the semi-arid, coastal lowland zones. *In: Proceedings of the 2nd Annual KARI Conference held on 5th-7th September 1990.* Pp.116-123.

Otieno, L., G. Kamau, M. Njunie, T. Munga, A. Blokland, B.M. Kikuvi, F Jefa, and P. Chege. 1994. Diagnostic survey using PRA techniques of Roka location, Bahari Division, Kilifi District.

Oppenoorth, F.J. 1976. Biochemical genetics of insecticide resistance. *Ann Rev. Ent.* 10: 185-206.

Reynolds, L., J. Muriithi, G. Mullins, and W. Thorpe. 1993. Food resource availability and milk production on small holder dairy farms in the sub-humid coastal region of Kenya. In: *Animal Production in Developing Countries.* Occasional Publication No. 16. British Society of Animal Production. Pp.158-159.

Swallow, K.A., 1996. Economic Development, Institutions, and Technique Change: Intensification of Cattle-Feeding Techniques by the Giriama of Kenya's Coast Province. PhD Thesis, University of Wisconsin-Madison.

Tabashnik, B.E. 1994. Evolution of resistance to *Bacillus thuringiensis. Annual Rev. Entomol.* 39: 47-79.

Unnithan, G.C. 1987. Development and reproductive biology of the maize stem-borer, *Busseola fusca* Fuller (Lepidoptera: Noctuidae). *J. Appl. Ent.* 104: 172-179.

Waaijenberg, H. 1994. Mijikenda Agriculture in Coast Province of Kenya: Peasants in Between Tradition, Ecology and Policy. PhD Thesis, Wageningen Agricultural University, The Netherlands.

Whalon, M., and D. Norris. 1996. Resistance management for transgenic *Bacillus thuringiensis* plants. *Biotechnology and Development Monitor* 29: 8-12.

Appendix A: Workshop on Integrating Pastures, Fodders, and Cereal Crops as Refugia for Stem Borers in the Farming Systems of the Humid Coastal Kenya, held at KARI-Mtwapa, 26-29 July 2004

PROGRAM

MONDAY, JULY 26, 2004

15:00 Participants arrive at KARI - Mtwapa Center - *Mr. B. Muli*

TUESDAY, JULY 27, 2004

08:00 Registration

Opening Session
CHAIR – Mr. Kimani, Provincial Crops Officer, Coast Province

08:30 Welcome, introductions and opening remarks - *Dr. R. Muinga, CD KARI-Mtwapa*
Remarks by Coordinator IRMA Project - *Dr. S. Mugo, CIMMYT ALP*

09:15 Official Opening speech by *Mr. Jacob Odondi, Provincial Director of Agric. (PDA)*

09:30 Objectives of the workshop - *Dr. M. Mulaa, Entomologist, KARI-Kitale*

Overview of the KARI/CIMMYT IRMA Project - *Dr. S. Mugo, CIMMYT ALP*

10:00 **TEA/COFFEE BREAK**

Sharing Experiences on Research and Extension Work on Fodders and Pastures in the Coast Province.CHAIR – Mr. Kimani, Provincial Crops Officer, Coast Province

10:30 Importance of refugia and on-going and future research work - *Dr. M. Mulaa*

11:30 Farming systems of Coast Province - *Mr. B. Muli, Agronomist, KARI-Mtwapa*

11:50 Major fodders/forages grown by farmers – DLOs Mombasa, Lamu, Kwale, Kilifi, Malindi, and Tana River districts

12:40 Types of natural pastures/fodders and grasses and their distribution in the coastal region - *Mr. S.M. Njagi, PAPO Coast Province*

13:00 **LUNCH BREAK**

Sharing Experiences on Research and Extension Work on Fodders and Pastures in the Coast Province.
CHAIR – Dr. D. Mwamachi, RELO-Research

14:00 Pasture/fodder research in coast region with reference to production and utilization - *Mr. A. Ramadhani and Mr. J. Kiura, Research officers, KARI-Mtwapa.*

14:30 Farmers experiences with growing and utilization of pastures, fodders, natural grasses and cultivated crops - *Farmers.*

15:30 **TEA/COFFEE BREAK**

Sharing Experiences on Research and Extension Work on Fodders And Pastures in the Coast Province.
CHAIR – Dr. D. Mwamachi, RELO-Research

16:00 Field visit to two livestock farmers near KARI Mtwapa – *Mr. A. Ramadhani and Mr. S. Bimbuzi*

15:30 End of Day 1

WEDNESDAY, JULY 28, 2004

	Practical Experiences with Refugia Species ***CHAIR - Mr. S. Abdillahi, Provincial Livestock Officer Coast Province***
08:00	Group exercises ranking of refugia species in the IRM experimental plot based on researcher, extension, farmer and individual criteria - ***Dr. M. Mulaa***
10:00	**TEA/COFFEE BREAK**
10:30	Group work, preparing information collected from the IRM experimental plot for presentation in plenary
10:30	Group presentations - 3 groups (Farmer, Extension, Researchers) and Synthesis and general discussions - ***Dr. M. Mulaa***
13:00	**LUNCH BREAK**
14:00	Harmonizing project researcher, extension and farmer performance indicators ***- Mr. J. Ndung'u, Socio-economist, KARI-Mtwapa***
14:30	Developing participatory monitoring and evaluation frame works ***- Mr. Danda Kengo, Socio-economist, KARI-Mtwapa***
15:30	**TEA/COFFEE BREAK**
16:00	***Closing Session*** ***CHAIR: B. Muli*** Farmer representative – ***Mr. Ahmed Mohamed*** Extension staff representative – ***Mr. J. Masha*** Center Director Mtwapa – ***Dr. R. Muinga*** Official closing - ***Mr. S. Abdillahi*** Vote of Thanks - ***Dr. S. Mugo*** **DEPARTURES**

Appendix B: Workshop Budget

Total 34 participants

PER DIEM			
(a)	Extension staff and farmers		
	26 participants x 3 days @ 2,500	=	195,000
(b)	Facilitators		
	1 facilitator (from Kitale) 6 days @ 3,000	=	18,000
	Embu + Kakamega 2 x 2,500 x 6 days	=	30,000
	SUB-TOTAL		
		=	243,000
TRANSPORT (Return)			
Kitale – Mtwapa (1)		=	6,000
Malindi – Mtwapa (4)		=	7,000
Tana River – Mtwapa (1)		=	7,000
Lamu – Mtwapa (4)		=	7,000
Kilifi – Mtwapa (4)		=	500
Kwale – Mtwapa (4)		=	500
Mombasa – Mtwapa (4)		=	4,000
Local running		=	6,000
	SUB-TOTAL	=	38,000
Teas @ 350 per person (x34 x2)		=	23,800
STATIONERY			
1 flip chart @ 600		=	600
2 CDs @ 500		=	1,000
21 folders @ 150		=	3,150
34 loose leaf pads @ 80		=	2,720
34 Biro pens @ 20		=	680
1 roll masking tape @ 250		=	250
2 reams printing paper @500		=	1,000
Envelops + Postage		=	1,000
Phone card		=	1,000
	SUB-TOTAL	=	7,750

BUDGET SUMMARY

ITEM	COST Ksh
Per Diem	243,000
Transport	38,000
Tea's	23,800
Stationery	11,400
GRAND TOTAL	**316,200.00**

Appendix C: Expected Participants

1. Farmers
15 farmers - Three from each of 5 districts – (Mombasa, Kilifi, Kwale, Lamu, and Malindi)

2. Extension staff:
- Provincial Director of Agriculture (PDA Coast)
- Provincial crops officer (Coast)
- Provincial Livestock Officer (Coast)
- Provincial Range Officer (Coast)
- Livestock production officers from 6 districts - (Mombasa, Kilifi, Kwale, Malindi, Tana River, and Lamu)
- Research – Extension linkage officer (RELO) -MOA Coast

3. KARI Research Staff:
- Centre director KARI Mtwapa (Dr. R. Muinga)
- Deputy Centre Director (KARI Mtwapa)
- IRM collaborating scientists (Mr. B. Muli)
- Pasture / fodder Agronomist (KARI Mtwapa)
- Animal nutritionist (KARI Mtwapa)
- Socio economist (KARI Mtwapa)

4. Facilitators
- Margaret Mulaa (KARI-Kitale)
- Stephen Mugo (CIMMYT)
- Danda Kengo (KARI-Mtwapa)

Total 35 participants

Appendix D: Payment Voucher

Payment for .... Date ....

Name	Amount	Signature
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
18		
19		
20		
21		
22		
23		
24		
25		

Appendix E: Invitation Letter

CIMMYT African Livelihoods Program
Int. Maize and Wheat Improvement Center (CIMMYT)
ICRAF House, United Nations Avenue, Gigiri
P.O. Box 25171 Nairobi, Kenya
Tel.: 254-2-524600/524610s

Date: July 16, 2004

Dear ……..

RE: INVITATION TO "INTEGRATING PASTURES, FODDERS AND CEREAL CROPS AS REFUGIA FOR STEMBORERS IN THE KENYAN FARMING SYSTEMS": A WORKSHOP TO BE HELD FROM JULY 26-29, 2004 AT KARI-MTWAPA, KENYA.

Stem borers are one of the major causes of low maize yields in Kenya and other parts of Africa causing losses estimated at 20-40%. New technologies that can reduce yield loss are necessary to increase maize production to cope with the increasing demand for maize in Kenya. The Insect Resistant Maize for Africa (IRMA) project aims at increasing maize production and food security through the development and deployment of stem borer resistant maize germplasm developed using conventional and biotechnology methods such as Bt maize. Bt maize offers farmers an effective practical option for controlling stem borers.

One concern of utilizing Bt maize technology is the likelihood of development of resistance to the Bt toxins by the target stem borer species. However, the rate of evolution of this resistance can be slowed or stopped through the implementation of appropriate resistance management strategies. To counter the build up of resistance to Bt maize, the IRMA project is developing varieties of maize that carry multiple forms of resistance as well as conventional resistance. In addition, resistance management strategies are being developed, the primary strategy being providing refuge to host plants that do not produce the toxins and can maintain populations of non resistant borers that will breed with potentially resistant borers and limit the build up of resistant insect populations. The Insect Resistant Management strategies developed must conform to existing cropping systems and the refugia crops must be economically viable and socially acceptable to the farmers. KARI and CIMMYT scientists are conducting research to characterize host suitability for stem borers using field trials and laboratory bioassays and farm surveys to map percent refugia at district level. Sorghums, fodders and forages have been found to be potential refugia, which could be utilized in the management of insect resistance.

For this reason, CIMMYT and KARI will conduct a two day workshop. As an interested partner, we wish to invite you to this workshop, which will run from July 26-29, 2004. at KARI-Mtwapa. This is about 25 km from Mombasa, along the Mombasa-Malindi road. Please plan to arrive at the KARI-Mtwapa Center by the afternoon of Monday, July 26, 2004.

Each participant is expected to make a Presentation. Power point, overhead projectors and flip charts will be available for presentation. Please bring a soft and hard copy of your presentation. Participants are required to give a brief presentation of any experiences they or their centers, districts, province have had in Fodder/Forage research or adoption, production, utilization and distribution at the Coastal region. Information such as average acreage per household; number and types of livestock; acreage under maize; sorghum; fodders/forages; varieties grown (common name, scientific name and local name); preferred varieties and reasons for preferring will be very relevant during discussions if it is included in the presentation.

The district livestock officers from Kilifi, Kwale Malindi and Lamu should select and come with 3 farmers from their districts. The farmers selected should be able to communicate and write in English; have livestock and fodders / forages in their farms; have leadership qualities and ability to significantly participate and contribute to the workshop. Each farmer will have to make a presentation on their experiences with growing and utilization of pastures, fodders, natural grass and cultivated crops as livestock feed; most preferred types in their communities and reasons for preferring; and estimates of pasture / fodder acreage per household in their farms and their communities.

CIMMYT will cover your travel expenses, in the form of reimbursement of receipts produced for public transport by road. A modest per-diem allowance will be provided to cover for your accommodation, dinner and other additional expenses. Please note that teas and lunches will be provided for. Also note that we have not made accommodation preparations, so you will be required to make your own arrangements.

Your presence and participation to this workshop will be greatly appreciated and we wish to request your early confirmation (by July 21st, 2004) to enable us make the necessary preparations to receive you. Kindly contact the Director KARI-Mtwapa on telephone 254-41-5485842 or e-mail irmamtw@africaonline.co.ke with your confirmation.

Sincerely,

Dr. Stephen N. Mugo
Coordinator IRMA Project

Cc: Dr. Rahab Muinga – Center Director, KARI Mtwapa

Appendix F: Displays and Materials Distributed

Posters
1. IRMA partnerships
2. Genetic engineering
3. Biotechnology in general

Stationery
1. One folder
2. One Pen
3. One notebook

Handouts
1. CIMMYT ALP flyer
2. Copy of the program
3. IRMA Project brochure

Appendix G: List of participants for workshop on integrating pastures, fodders and cereal crops as refugia for stem borers in the farming systems of the humid coastal Kenya, July 26-29, 2004, KARI Mtwapa

IAME		JOB TITLE / DESIGNATION	INSTITUTION	DISTRICT	ADDRESS	TELEPHONE	EMAIL
1	Mr. A.I. Kimani	PCO	MOA/Province	Coast	PO Box 90290 Mombasa, KENYA.	733 973028	pdacoast@kenyweb.com
2	Mr. Ahmed Mohammed	Farmer	Farmer	Lamu	PO Box 225 Lamu, KENYA.	721-469476	-
3	Mr. Ali Ramadhan	Senior Research Officer	KARI	Kilifi	PO Box 16 Mtwapa, KENYA.	41-5486207	karimtw@africaonline.co.ke
4	Mrs. Anna B. Tsani	Farmer	Farmer	Kwale	PO Box 40 Kwale, KENYA.	722-401226	-
5	Mr. Benjamin M. Muli	Senior Research Officer	KARI	Kilifi	PO Box 16 Mtwapa, KENYA.	722-841390	irmamtw@africaonline.co.ke
6	Mr. Changawa Charo	Farmer	Farmer	Malindi	PO Box 51 Gede, KENYA.	-	-
7	Dr. D.M. Mwamachi	Senior Research Officer /RELO Research	KARI	Kilifi	PO Box 16 Mtwapa, KENYA.	722-696598	karimtw@africaonline.co.ke
8	Mr. Danda Kengo	Research Officer	KARI	Kilifi	PO Box 16 Mtwapa, KENYA.	733-867537	dkengo@yahoo.com
9	Dr. Margaret Mulaa	Senior Principle Research Officer	KARI	Transzoia	PO Box 450 Kitale, KENYA.	722-382769	irmaktl@africaonline.co.ke
10	Dr. S. Ajanga	Senior Research Officer	KARI	Kakamega	PO Box 169, Kakamega, KENYA.	722-681283	kari_kk@swiftkisumu.com
11	Dr. Stephen Mugo	Scientist	CIMMYT	Nairobi	PO Box 25171-00603, Nairobi, KENYA.	020-524600 , 0733-720297	s.mugo@cgiar.org
12	Mr. E.M. Kiruiro	Senior Research Officer Animal Nutrition	KARI	Embu	PO Box 27, Embu, KENYA.	68-20873, 0722-303881	ekiruiro@kariembu.org
13	Mr. Emmanuel Yaa	Farmer	Farmer	Kilifi	PO Box 228, Kilifi, KENYA.	-	-
14	Mr. Fred Jefa	DLPO	Livestock	Lamu	PO Box 267, Lamu, KENYA.	734-719236	-
15	Mr. Francis Kangunu	DLPO	MoL/FD	Kwale	PO Box 186, Kwale, KENYA.	722-865117	-
16	Mrs. Grace Ambajo	Technical Assistant	KARI	Kilifi	PO Box 16, Mtwapa, KENYA.	722-638350	-
17	Mr. Hassan A. Ableilty	Farmer	Farmer	Lamu	PO Box 89962, Mombasa, KENYA.	722-783871	-
18	Mr. J.M. Ndungu	Research Officer	KARI	Kilifi	PO Box 16, Mtwapa, KENYA.	722-780300	Ndungua@yahoo.com
19	Mr. J.N. Kiura	Senior Research Officer Livestock	KARI	Kilifi	PO Box 16, Mtwapa, KENYA.	733-297875	Ndwmut@yahoo.com
20	Mr. J.S. Masha	DLPO	Livestock	Tana River	PO Box 116, Hula, KENYA.	46-62027	-
21	Mr. M.A. Bandari	Farmer	Farmer	Kwale	PO Box 67, Kwale, KENYA.	734-654576	-
22	Mr. M.S. Njagi	PAPO Coast	PDLP's office	Provincial HQs.	PO Box 90725, Mombasa, KENYA.	720-908184	-
23	Mr. O.D. Morowa	DLPO	Extension	Malindi	PO Box 120, Malindi, KENYA.	42-20505, 0733-373991	º
24	Mr. O.M. Mwanzau	DLPO	MoL/FD	Mombasa	PO Box 97037, Mombasa, KENYA.	722-865465	-
25	Omari Mwamarifa	Farmer	Farmer	Kwale	-	734-796406	-
26	Mr. Raymond Pole	Farmer	Farmer	Malindi	PO Box 51, Gede, KENYA.	-	-
27	Mr. S. Abdillahi	PEC Coast	PDLP's office	Coast	PO Box 90725, Mombasa, KENYA.	227283	-
28	Mr. S.W. Mukuna	DLPO	Livestock	Kilifi	PO Box 553, KENYA.	733-898662	-
29	Mr. Said B. Kofonde	Farmer	Farmer	Lamu	PO Box 30, Witu, KENYA.	41-633281	-
30	Mr. Salim M. Khal	Farmer	Farmer	Lamu	PO Box 225, Lamu, KENYA.	721-627383	º
31	Mr. Samuel Bimbuzi	Laboratory Technician	KARI	Kilifi	PO Box 16, Mtwapa, KENYA.	-	-
32	Mrs. Serah Luwali	Farmer	Farmer	Malindi	Malindi	-	-
33	Dr. Rahab Muinga	Center Director	KARI-Mtwapa	Kilifi	PO Box 16, Mtwapa, KENYA.	-	-

IBSN: 970-648-133-8

CIMMYT®
International Maize and Wheat Improvement Center
Apartado Postal 6-641, 06600 Mexico, D.F., Mexico
www.cimmyt.org