Kiboko Crops Research Station

A brief and visitors' guide

KARI

CIMMYT

The International Maize and Wheat Improvement Center, known by its Spanish acronym, 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 Kenya Agricultural Research Institute (KARI) is the premier national institution bringing together research programs in food crops, horticultural and industrial crops, livestock and range management, land and water management, and socio-economics. KARI promotes sound agricultural research, technology generation and dissemination to ensure food security through improved productivity and environmental conservation. KARI's mission is to develop and disseminate appropriate agricultural technologies in collaboration with stakeholders. KARI further contributes to the sustainable improvement in livelihoods of Kenyans by increasing agricultural productivity, and postharvest value of agriculture

Citation: CIMMYT. 2013. Kiboko Crops Research Station: A brief and visitors' guide.: CIMMYT.

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1.0 Background

The KARI-Kiboko sub-Station for Crops Research occupies part of the KARI-Kiboko Range Research Center land, but is a sub-Center of the KARI-Katumani Centre located in Machakos County. KARI-Katumani has the mandate to carry out adaptive and research and development programs in the semi-arid Counties of Machakos, Makueni, Kitui and Taita Taveta. These counties cover a total land area of 6.2 million hectares out of which 3.9 million is agricultural land.

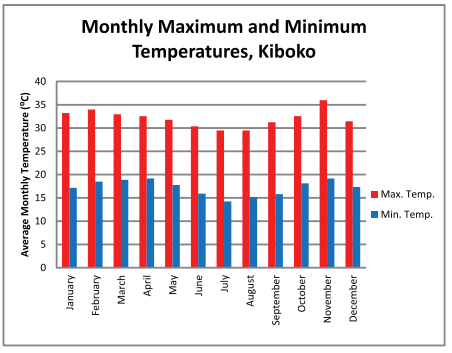
1.1 Administrative and geographic location

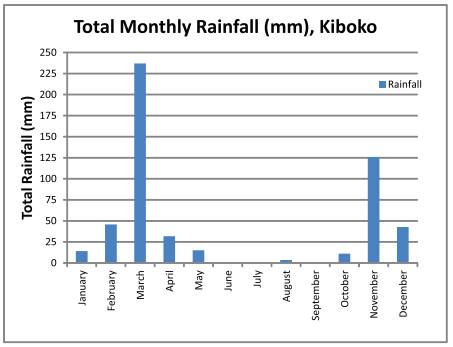
KARI-Kiboko Crops Research Station is located in Kiboko location, Makindu Division, Makindu District, Makueni County. It is about 155km from Nairobi along the Nairobi-Mombasa Highway, about 12 km before Makindu Town.

KARI-Kiboko lies within longitudes 37.7235°E and latitudes 2.2172°S. The farm is surrounded by the Kyulu Hills to the South, agro-pastoral Kamba community to the North and East and the pastoral Maasai community to the West. Previously, Kiboko was a hunting ground for licensed hunters of wild game animals.

1.2 Elevation rainfall and temperatures

Kiboko lies 975 m above sea level. The station receives between 545 and 629 mm of rainfall coming in two seasons. The long rains season is between April and May while the short rains season is between October and January. This is a hot dry region with a mean annual temperature of 22.6°C, mean annual maximum of 28.6°C and mean annual minimum of 16.5C.





1.3 Soils

The soils are well drained, very deep, dark reddish brown to dark red, friable sandy clay to clay (Acri-Rhodic Ferrassols) developed from undifferentiated basement system rocks, predominantly banded gneisses.

2.0 Historical background

The KARI-Kiboko sub-Center for crops research has a total of 155 ha, of which 43 ha are under development.

The sub-Center was started in 1985 by breeder scientists from KARI-Katumani who were attracted by the presence of Kiboko spring that could supply irrigation water throughout the year. The KARI-Katumani scientists started of the sub-Center with the development of 8.1 ha. This was increased to 20 ha when the International Crops Research Institute for the Semi-Arid-Tropics (ICRISAT) started research work on sorghum, pigeon pea and millet at the station in 1990. This is what is now called the Main Farm.

In 1997, Alpha Diallo initiated CIMMYT research work at Kiboko under the African Maize Stress Project. He established 2 ha each of low nitrogen and managed drought plots. In 2000, the Insect Resistant Maize for Africa (IRMA) Project started conventional breeding work on maize resistant to stem borers. However, these were on very small experimental plots in the current Main Farm that occupies about 30 ha.

KARI National Range Research Center, Kiboko

This is one of KARI's 22 research centers strategically spread across the country. The Centre was established in 1969 and assigned national responsibility of undertaking range research on constraints that affect rangeland productivity. The Center occupies 15,400 acres down from 37,000 acres when it was started. This encompasses research in all aspects of rangeland management and utilization with a view to generate information toward provision of guidelines and inform policy. Currently, this is being addressed together with KARI Research Centre at Marsabit. Both on-farm and on-station research is undertaken. The focus for on-farm activities is in the pastoral and agro-pastoral production systems, mainly in the larger Makueni, Taita-Taveta, Kajiado and Narok Districts.

The increased research projects and activities have expanded the acreage under crops research. CIMMYT-KARI Kiboko Research Center now occupies about 215 ha in nine distinct farms: two drought screening farms, two seed multiplication farms, a doubled haploid production farm and three confined field sites to test transgenic maize and sorghum. Each of the farms has a secure electric fence to prevent damage of crops by wildlife and has water for overhead or drip irrigation.

3.0 Kiboko Crops Research Farms

	Farm	Area (Ha)	Main activity
1	Drought Screening site	42	Screening for drought tolerance and low nitrogen tolerance
2	ICRISAT Farm	13	Research work on sorghum, pigeon pea and millet
3	KARI Main Farm	30	KARI, CIMMYT and ICRISAT work
4	KSU Seed Farm	25	Multiplication of breeders' and certified seed for scheduled crops for seed industries and farmers
5	WEMA transgenic maize (insect resistance and drought tolerance) Confined Field Trial (CFT) Farm	3	Evaluate performance of transgenic maize for resistance to stem borers (*Chilo partellus* and *Busseola fusca*); and drought tolerance
6	Africa Biofortified Sorghum (ABS) project CFT	1	Evaluate the performance of biofortified sorghum
7	Nitrogen use efficient maize CFT	2	Development of transgenic varieties with increased yield under severe N-limitation
8	Cassava Seed Multiplication Farm	34	Cassava seed multiplication
9	Doubled haploid (DH) production farm	25	Generate DH lines

3.1 CIMMYT drought tolerant maize screening site

The entry of Drought Tolerant Maize for Africa (DTMA) project in Kiboko in 2007 brought more pressure on the available land under crop research. To meet the increasing demand for research land, CIMMYT successfully applied for a further 25 ha from KARI and developed it into what it is now referred to as the New Site Farm. To avoid cross pollination, a 400 meter buffer zone was left between the Main Farm and the New Site.

The Water Efficinet Maize for Africa (WEMA) project, started in 2008, acquired 2 ha from the Cassava Farm for its trials. But this was not enough. CIMMYT again successfully applied to KARI for an additional 6 ha to be

added to the New Site for WEMA trials, with a further 20 ha being granted to CIMMYT in 2011, increasing the acreage of the New Site Farm to 115 acres.

An additional 20 ha has just been developed for use by all projects making the total of land for drought screening at 42 ha.

CIMMYT regional maize stress screening farm office

3.2 ICRISAT Cereal and Legume Farm

ICRISAT started its activities at Kiboko in 1989 and now has 13 ha under development and management. It conducts research on cereals (sorghum, pearl and finger millets) and legumes (pigeon peas). ICRISAT work at Kiboko is implemented through three major projects:

- **Harnessing of Opportunities and Productivity Enhancement** (HOPE) of Sorghum and Millets in Sub-Saharan Africa and South Asia project that seeks to help smallholder farmers increase the yields of the two dryland cereal crops.

- **Tropical Legumes II (TL II)** project that aims to improve the livelihoods of smallholder farmers in the drought-prone areas of sub-Saharan Africa (SSA) through enhanced productivity and production of the five grain legumes: cowpea, groundnut, chickpea, soybean, and pigeonpea. Activities at Kiboko are focused on cowpea, groundnut, chickpea, and pigeonpea

- **Sorghum for Multiple Uses (SMU)** that supports the development and demonstration of new multipurpose sorghum varieties that are high yielding and adapted to both biotic and abiotic stresses in eastern Kenya and northern and central Tanzania.

3.3 KARI Main Farm

The Main Farm has a KARI farm office, a postharvest screening laboratory, quality protein maize (QPM) laboratory, ICRISAT offices, and the KARI Guest House. KARI has obligations to stakeholders such as water rights and community links. The station supports crops research by KARI national program, CIMMYT and ICRISAT regional programs. Besides supporting these programs, KARI scientists are conducting their own research on three crop types: cereals (maize, sorghum, and pearl and finger millets); legumes (beans, lablab, cowpeas, green and yellow grams, pigeon peas and chickpeas); and roots and tubers (cassava and sweet potatoes). The KARI team at Kiboko consists of an Officer-in-Charge, nine scientists and one technician.

3.4 KSU Seed Farm

In 2000, the KARI Seed Unit (KSU) developed 20 ha for seed multiplication of crop varieties not prioritized by commercial seed sector but highly sought after by farmers such sweet potatoes and cassava. KSU objective is to multiply breeders and certified seed for scheduled crops for seed companies and farmers. KSU has moved the bulk of seed multiplication to farmers' fied and therefore currently only 40% of the KSU farm is utilized for seed multiplication, with the rest now under KARI and CIMMYT research activities.

3.5 Drought tolerance and insect resistance CFT

IRMA acquired 1 ha in 2005 for the development of a quarantine facility for breeding Bt maize. From 2010, the Water Efficient Maize for Africa (WEMA) project has been conducting confined field trials (CFTs) on MON87460 - a genetically modified maize developed to tolerate moderate drought. The project has so far conducted four CFTs on drought tolerance, the latest having been planted fourth of these trials was planted on 28 November 2012, and harvested on 16 April, 2013. The project is also in its second CFT for MON810 – a Bt maize developed for resistance to stem borers (*Chilo partellus* and *Busseola fusca*).

Entrance to the drought tolerance and insect resistance CFT at Kiboko

3.6 IMAS CFT

In 2012, IMAS project acquired 2 ha of land for the establishment of a CFT to evaluate promising nitrogen use efficient (NUE) constructs in tropically adapted maize germplasm. In partnership with the KARI and the National Biosafety Authority (NBA) in Kenya, development of a 2 ha CFT site commenced in March 2013. One hectare of the CFT will be depleted of nitrogen to evaluate the efficacy of transgenic varieties vis-à-vis their conventional versions under low nitrogen. The other one hectare of the site will be used to evaluate transgenic and conventional versions under optimal conditions to ensure that there is no yield drag under well managed conditions. Mock trials will be undertaken in 2014 and it is expected that the first transgenic conversions will be evaluated at the sites in 2016.

3.7 Sorghum CFT

This is a project of Africa Harvest in partnership with Pioneer and KARI to develop transgenic sorghum containing provitamin A, improved sorghum protein quality, digestability, enhanced iron and zinc availability

Africa Biofortified Sorghum (ABS) CFT at Kiboko

3.8 Doubled Haploid facility

CIMMYT has also acquired another 20 ha for development of a Double Haploid facility.

DH facility under development at Kiboko

3.9 Cassava Farm

In 2009, KARI scientists decided to use the 20-ha buffer zone for cassava research - as it does not cross pollinate with maize – and consequently named it the Cassava Farm. The farm is being used to produce cassava cuttings by KARI-Katumani Cassava Program for distribution to farmers by the Ministry of Agriculture, Livestock and Fisheries.

4.0 CIMMYT-KARI Maize Improvement Program

KARI-Kiboko plays a pivotal role in breeding of dryland crops and seed multiplication. It serves as a variety testing and seed bulking site due to its all-year-round irrigation facilities. The CIMMYT-KARI Maize Program at the center seeks to assemble and evaluate maize germplasm, and develop varieties that are resistant to abiotic (drought, heat, and edaphic) and biotic (including stem borers, weevils, larger grain borer, aphids, maize streak and head smuts) factors. It also develops sustainable husbandry (agronomic) technologies that maximize yields at both low and optimal input levels.

Polination in a DH nursery at Kiboko

CIMMYT maize related activities currently undertaken at Kiboko include:

1. Maize breeding for drought tolerance using conventional and molecular markers in the DTMA project and using conventional and molecular markers and transgenic technology in the WEMA project.

2. Maize breeding for resistance to stem borer and postharvest insect pests through conventional breeding in the IRMA projects and through transgenic BT maize in the WEMA project.

3. Maize breeding for resistance to foliar diseases (maize streak virus (MSV), Turcicum leaf blight, and gray leaf spot (GLS)) in all projects.

4. Maize breeding for tolerance to low soil nitrogen using conventional, marker assisted and transgenic technologies in the Improved Maize for African Soils (IMAS) project.

5. Multiplication and bulking of seed of improved maize germplasm.

6. Development of doubled haploid homozygous lines for use in further breeding for stress tolerance.

The activities are carried out in collaboration with KARI and other stakeholders.

The current CIMMYT research at Kiboko is implemented through four major projects: 1) Drought Tolerant Maize for Africa (DTMA); 2) Combining Breeding and Biotechnology to Develop Drought Tolerant Maize for Africa (WEMA); 3) Improved Maize for African Soils (IMAS); and 4) Developing Maize Resistant to Stem Borer and Storage Insect Pests for Eastern and Southern Africa (IRMA III Conventional project). The major donors are the Bill & Melinda Gates Foundation (BMGF), the Howard Buffet Foundation, United States Agency for International Development (USAID) and the Syngenta Foundation for Sustainable Agriculture (SFSA). Each of these projects is briefly described below:

4.1 Drought Tolerant Maize for Africa

Launched in 2006, the DTMA project aims to mitigate drought and other constraints to maize production in sub-Saharan Africa, increasing maize yields by at least one ton per hectare and with a 20-30% increase over farmers' current yields, benefiting 30-40 million people in 13 African countries. It is jointly implemented by CIMMYT and the International Institute for Tropical Agriculture (IITA), in close collaboration with KARI and other national agricultural research systems (NARS) in 13 participating countries. Achievements so far include:

- Sixty drought tolerant hybrids and 57 open pollinated varieties (OPVs) released to smallholder farmers. The released varieties are also resistant to major diseases that include maize streak virus, northern leaf blight, and gray leaf spot.

- About 29,000 tons of seed was produced in the 2011/12 season alone - enough to sow more than 1.1 million hectares, benefiting about 2.9 million households or 20 million people. Production of drought tolerant maize seed could reach 60,000 tons by 2016.

4.2 Improved Maize for African Soils project

The IMAS project aims at developing varieties of maize for small holder farmers in southern and eastern Africa that are more responsive to low doses of fertilizer that characterize maize production in the region. Achievements include: 1) Establishment of the largest, tropical phenotyping network (90,000 research plots in 8 countries in southern and eastern Africa) for identification of nitrogen use efficient products. 2) Identification and distribution of NUE donor inbreds to public and private institutes in Africa, Asia and Latin America. 3) Release, production and marketing support for NUE hybrids in four countries (Kenya, Uganda, Tanzania and Zimbabwe) in collaboration with the private seed sector.

4.3 Insect Resistant Maize for Africa project

IRMA's overall goal is to develop and deploy maize varieties resistant to field and storage insect pests for eastern and southern Africa. IRMA has already:

- Enhanced the capacity of insect screening for pre and postharvest was enhanced to support screening of at least 10,000 rows
- Released of 13 stem borer resistant (SBR) conventional maize varieties (3 open-pollinated varieties (OPVs) and 10 hybrids) and four storage pests resistant (SPR) hybrids in Kenya.
- Developed 2nd generation SBR and SPR germplasm.
- Assessed the extent of stem borer pests and postharvest losses in high priority areas of the eastern and southern African maize belt

4.4 Water Efficient Maize for Africa project

WEMA aims to develop drought tolerant and inset protected maize for SSA through effective integration of conventional breeding, doubled haploid (DH) technology, marker-assisted recurrent selection (MARS) and transgenic technology. Achievements include:

- One hybrid (WE1101) commercialized, and two other hybrids recommended for commercial release in Kenya in 2013
- 15 hybrids in year 2 of NPT testing in Kenya, Uganda and Tanzania
- 27 hybrids in year 1 of NPT testing in Kenya, Mozambique South Africa, Tanzania and Uganda.
- About 10,000 DH lines developed from nearly 150 CIMMYT maize populations.

- Completed the largest public MARS program with >25 bi-parental populations evaluated under 2-3 managed drought stress & 3-4 well-watered environments and conducted 3 cycles of rapid cycling using markers only selection.
- Four seasons of confined field trials (CFT) completed on DT transgene in Kenya, South Africa and Uganda with promising results
- The second seasons of CFT for Bt insect-pest protection transgene started in 2013; currently in CFT in Kenya and Uganda with promising results

4.5 Effective Grain Storage for Sustainable Livelihoods of African Farmers project

Funded by SDC, the goal of Effective Grain Storage for Sustainable Livelihoods of African Farmers Project (EGSP) is to enhance household food security by reducing postharvest losses and increasing incomes of target farmers' through provision of improved postharvest technologies, informed policy and capacity building for scale up. EGSP focuses on 3 pillars of postharvest: technology, policy and market. In each of the target countries (Kenya, Malawi, Zambia and Zimbabwe) the project will strategically focus on areas with a relative surplus production of maize, which is stored for months before consumption or sales, and where storage pests are perceived as a major problem. The project activities include:

- Distribution of over 16000 metal silos and reaching 24000 households with hermetic bags by 2016 in the four target countries of Kenya, Malawi, Zambia and Zimbabwe.
- Training of local artisans, national research partners and extension workers in postharvest loss assessments and improved grain storage technologies
- Reviewing agricultural policies that affect postharvest management and holding policy dialogues with national policy makers
- Establishment of screening facilities for maize weevil and larger grain borer (LGB) at Kiboko.

The Kiboko Post-harvest Laboratory was built in 1990 with funds from the Department for International Development (DfID) of the British Government. This was an outreach laboratory of the Kenya/UK Larger Grain Borer Research Project, coordinated from KARI – NARL (National

Choice postharvest screening of maize ears for rsistance to maize wevil and the larger borer at the post harvest lab, Kiboko

Agricultural Research Laboratory). Maize varietal screening for resistance to storage insect pests—maize weevil (*Sitophilus zeamais* Motsch.), and larger grain borer (*Prostephanus truncatus* Horn) began in 2001. The first phase of the KARI-CIMMYT - IRMA I Project (1999–2003) rehabilitated the initial two rooms, stocked glass jars, installed light tables and some 210-liter capacity plastic drums for fumigation. CIMMYT and KARI have continued to use the facility and expanded it to its current capacity that can screen maize kernels in about 10,000 jars in a cycle of three months.

4.6 DH facility

The facility, funded by BMGF, is being developed to strengthen the maize breeding programs in SSA through faster development of improved maize hybrids using DH technology. The facility will generate 60,000 DH lines annually, sufficient to serve the entire breeding program requirements of CIMMYT and IITA, and a large proportion of NARS and private sector requirements in SSA. The project will initially focus on implementing and operating the DH service with existing technology, but some strategic research will be conducted aimed at reducing the cost of DH line production, improving the throughput and efficiency, and to verify the efficiency of the DH approach relative to other breeding methods under African conditions. These will include:

- Continued development of improved, second-generation tropically-adapted inducer lines that can be freely distributed to CIMMYT partners
- Identifying alternative chromosome doubling agents that are less expensive and environmentally safer as compared to the currently used colchicine

- Developing new phenotypic markers that allow more efficient identification of haploids
- Optimizing agronomic management to increase the DH line recovery rate from the current 17% to more than 30%.

5.0 Physical resources

The New Site has three offices, a cold store, a farm input store, a seed store, an implement shade, one working shade and a sanitation block. At the Main Farm, there are two office blocks build by CIMMYT, a postharvest screening laboratory that was build by KARI but maintained and used by CIMMYT, a cold store, guest house that was built by ICRISAT and donated to KARI.

KARI guest house at Kiboko

6.0 Human resources

6.1 Management

Overall Station Manager	**Mr. Peter Mutali Simiyu**
Manager CIMMYT Activities	**Mr. Joel Mbithi**
Manager ICRISAT activities	**Patrick Sheunda (Sorghum)/Enos Ochieng' (Pigeon pea)**
Manager WEMA CFT	**Mr. Joel Nyamai**

6.2 Maize research technical staff

The CIMMYT-KARI Kiboko sub-Center is run by a CIMMYT Farm Manager assisted by nine technicians. All the technicians have undergone training in Agriculture at certificate level.

6.3 Semi-skilled staff

The station has 26 contracted casuals with semi-skills for normal farm and research operations.

6.4 General labor

On average Kiboko sub-Center employs 200 field staff on daily basis and upto 1000 staff monthly thus supporting a significant proportion of the Kiboko town human population.

6.5 Training

Kiboko attracts a significant number of Diploma and BSc on resident industrial attachment for two or more months. MSc and PhD students typically conduct resident thesis research under the supervision of KARI and CIMMYT scientists. In addition Kiboko is the training ground for visiting scientists, and occasional maize breeding course participants.

7.0 Challenges at the sub-Center

- Wild animals such as elephants and buffalos cause great damage to experimental fields, a situation that has forced CIMMYT and partners to install electric fences around the crop fields. Snakes and lions are a huge threat to workers' safety.
- Irrigation water: there is overreliance of the Kiboko spring to supply water but this is becoming difficult to sustain with the expansion of irrigated fields at the station. The Water Regulatory Authority only allows for irrigation to be done from 6pm to 6am which raises operational cost. This increases the labor costs as the field attendants have to be paid extra allowances for working at night which in turn puts them at a much higher risk of attacks from wild animals.
- High water salinity that increase maintenance costs of the aluminium pipes used for irrigation.
- Lack of adequate number of equipment's including tractors, drip irrigation.
- Lack of affordable, clean and hygienic guesthouse or hotel.
- Inadequate cold storage facilities.
- Lack of quality staff rental houses.

CIMMYT

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