Kenya Agricultural and Livestock Research Organization

Agricultural Mechanization Research Institute
KATUMANI

2016-2017 research highlights

Compiled by Arnold Njaimwe, Daniel Mutisya and John Ayemba
July 2017
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Enhancing crop production and livestock keeping in arid and semi-arid lands through appropriate breeding and husbandry intervention strategies

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Cover: Rachael Kisilu explains how the walking tractor works during the 2017 Agricultural Society of Kenya Machakos Show

Photographs by: John Ayemba and Cheran Ariithi

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P.O. Box 340-90100 Machakos, Kenya Mobile 254-0710906600
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1 Agricultural mechanization

1.1 Programme mandate
The institute has the national mandate of generating and disseminating agricultural mechanization technologies and innovations on crops and livestock value chains in Kenya to increase agricultural productivity, improve post-harvest value of crops and livestock products and conserve the environment.

The Agricultural Mechanization Research Institute is located at Katumani in Machakos County (1° 35'S and 37° 14'E) at an altitude of about 1600 m above sea level, about 80 km southeast of Nairobi, and about 9 km South of Machakos town, along the Machakos-Wote Road. The institute has Katumani Research Centre and four sub-centres which are Kiboko, Masongaleni, Ithookwe (Makueni County) and Voo and Kampi ya Mawe (Kitui County).

The main tasks during the year were:

- To review and approve project annual work plans and related budget to ensure adherence to project development activities
- Provide guidance to project management and resolve issues that may arise during the project implementation
- Monitor performance of project and advise on policy issues

1.2 Achievements
- Kenya Government received a grant of KES 10 billion from India for the purpose of enhancing the use of machinery especially for small scale farmers. The overall objective of the project is to transform smallholder farming from subsistence to modern, commercially oriented and competitive entities through mechanization of the agricultural production systems and increase productivity. KALRO was appointed to be a member of the Steering Committee on agricultural machinery on distribution
- Review of work plans and budget based on the project goals
- Rationalization of the agricultural machinery requirements for all the 47 counties (in 10 cluster regions) together with other steering committee members, from 19-30 June 2017. The machinery is meant for farm operations including, ploughs, subsoilers, harrows, rotavators, cultivators, planters, boom sprayers, harvesters/threshers, trailers and baling machines. During this exercise the grant conditionalities as well as delivery schedule were discussed.
- A report on the baseline survey on the status of agricultural mechanization in Kenya
- A report on challenges and solutions for agricultural mechanization to small holder farmers; the case of Africa, Presented to an International Symposium of Agricultural Commodity Trade, RDA, Jeonju, South Korea.
- Technology dissemination through field days in Kitui, Taita Taveta and Uasin Gishu counties.
- Agricultural shows in Eldoret (Uasin Gishu County), Machakos and Kitui Counties and International Trade Fair in Nairobi
- Capacity building of stakeholders (engineers, technicians, artisans, processors and scientists) on diversification of maize products through Nixtamilization process (cooking maize in lime).
- Partnerships on agricultural mechanization with stakeholders (MoA-agricultural engineering services (AES) and Agricultural Technology Development Centre (ATDC), The Korea-Africa Food and Agriculture Cooperation Initiative (KAFACI), National Irrigation Board, Farm Concern International among others) strengthened.

- A draft report on Agricultural Mechanization Research Institute strategic implementation plan, 2016-2020
- Evaluated agricultural mechanization technologies (harvesting methods for cassava and deficit irrigation for grain amaranth).
- Interview by KTN TV on Avocado oil press entrepreneurship
Hastening Ripening of Fruits

Participation in ploughing contest at KALRO Katumani
2  Crop health

2.1  Programme mandate
The programme undertakes development of technologies on crop health which are readily applicable to specific farming systems; biological, cultural, physical, chemical and integration of options. The programme has twin laboratory serving the units of Pathology and Entomology Sections.

2.2  Achievements

2.2.1  Pathology
The following activities were carried out to achieve specific milestones towards specific areas:

- Work on efficacy trials on two *Striga mycoherbicide* products granted by PCPB, products of Kichawi Kill 1 and Kichawi Kill 2 continued.

2.2.2  Entomology
Three milestones were achieved on sorghum protection against (i) birds and (ii) bollworm damage; and (iii) red spider mite pest abundance on various Brachiaria cultivar preference in different environments.

1.2.3  Key findings
A technology where sorghum grain is harvested at soft dough, then the panicles subjected to sunshine drying for 3-4 weeks was validated at KALRO-Katumani, Ithookwe and Kampi-Mawe during the period of 2016 production seasons. The results showed over 92% yield gain at cream-white stage. In 2017 the 124 farmers participated in training on sorghum harvest at soft dough and subsequent drying.

![Bird species](image)

*Serinus reichenowi, Plocepasser mahali and Quelea quelea*

![Graph](image)

*Bird species abundance and causing highest sorghum grain loss in eastern Kenya in 2016-2017*
Right time to spray against bollworm on sorghum was determined to be at anthesis stage, where efficiency control was 100% at the three sites of KALRO-Katumani, sub-centres of Ithookwe and Kampi-Mawe.

Bollworm caterpillars damaging sorghum grain at soft dough stage

Farmers participatory training on bird and bollworm management at Kwa-Ndeke in Yatta
Red spider mite infestation levels on Brachiaria grass was determined through an evaluation survey in Kitui (warm-wet), Katumani (warm-dry), Eldoret (cool-wet), Kitale (cool-wet), Alupe (warm-wet), Ol Joro Orok (cold-wet) and Mtwapa (warm-wet). Highest mite densities were observed in the dry environment of eastern and western regions. In these regions a management method will be developed commensurate with safe animal feeds ethical approach. Molecular identification results showed that the mite species was *Tetranychus urticae* (Koch).

<table>
<thead>
<tr>
<th>Site</th>
<th>No. mites/leaf (mean of 10 leaves)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machakos</td>
<td>12.3</td>
</tr>
<tr>
<td>Kitui</td>
<td>13.2</td>
</tr>
<tr>
<td>Eldoret</td>
<td>4.2</td>
</tr>
<tr>
<td>Kitale</td>
<td>6.7</td>
</tr>
<tr>
<td>Busia</td>
<td>5.3</td>
</tr>
<tr>
<td>Ol Joro Orok</td>
<td>0</td>
</tr>
<tr>
<td>Mombasa</td>
<td>0</td>
</tr>
</tbody>
</table>

Climatic conditions and red mite pest abundance in varied sites of Kenya, 2016
3 Sorghum agronomy

3.1 Programme mandate
The objective of the programme is to assemble and evaluate sorghum and millet germplasm, and develop varieties that are resistant to abiotic (drought, heat, and edaphic factors) and abiotic (stem borers, kernel covered smuts, aphids, charcoal rot, head smuts, foliar diseases, etc) stresses of the ASAL areas. The programme also develops sustainable sorghum and millet husbandry technologies that maximize yields at low input levels.

3.2 Achievements

3.2.1 Evaluation of sorghum elite lines for semi-arid dry highlands of Kenya
Eighteen different open pollinated sorghum genotypes bred for dry highland zones were evaluated under rain fed conditions for yield potential, tolerance to drought, diseases, pests and low temperatures (coldness) at Naivasha and Laikipia-Sipili. Naivasha has a semi-arid climate with a mean monthly temperatures of 17 °C (maximum 27 °C, minimum 7.9 °C), altitude of 1,889 m, and annual rainfall of 600-650 mm with bimodal seasons in March to May and October to December. The Laikipia sipili site is 1,700 m, the rainfall seasons are March to May and October to December, and an annual rainfall of 700 mm and temperatures of 16.6 °C with 7.4-25.5 °C.

3.2.1.1 Key findings
In both sites the precipitation was highest in April. The rainfall started in late April and declined in subsequent months. The crop was planted in early April hence in May it was in vegetative stage and flowering started in June when precipitation was declining.

The average yield was 2088 kg ha\(^{-1}\) (Table 1). Four genotypes IESV91069LT (2,978 kg ha\(^{-1}\)), Nyundo (2,978 kg ha\(^{-1}\)), IS-9203 (3165 kg ha\(^{-1}\)) and ABALASYA (3,483 kg ha\(^{-1}\)) had higher yield (P<0.05) than the checks; Gadam (1068 kg ha\(^{-1}\)), E 1291 (2795 kg ha\(^{-1}\)) and KARI Mtama1 (2505 kg ha\(^{-1}\)) indicating their superiority in grain yield. ABALASYA, IS-9203, IESV91069LT and KM 62 had the longest panicle exertion (≥ 5 cm) indicating their drought tolerance.

Table 1. Mean performance for the 18 sorghum genotypes planted at Naivasha and Laikipia-Sipili in March-May 2015 season

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Yield (kg ha(^{-1}))</th>
<th>Days to 50% flowering</th>
<th>Panicle exertion (cm)</th>
<th>Stand count</th>
<th>Harvested panicles (No)</th>
<th>Panicle length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KM 13</td>
<td>618</td>
<td>78.3</td>
<td>1.5</td>
<td>33.3</td>
<td>18.3</td>
<td>18.5</td>
</tr>
<tr>
<td>KM 3</td>
<td>683</td>
<td>78.3</td>
<td>0.75</td>
<td>21.5</td>
<td>25.8</td>
<td>20.0</td>
</tr>
<tr>
<td>KM 54</td>
<td>948</td>
<td>59.3</td>
<td>3.75</td>
<td>28.3</td>
<td>18.3</td>
<td>17.8</td>
</tr>
<tr>
<td>Gadom (check)</td>
<td>1068</td>
<td>62.5</td>
<td>8.25</td>
<td>41.3</td>
<td>64.0</td>
<td>18.0</td>
</tr>
<tr>
<td>KM 14</td>
<td>1235</td>
<td>76.8</td>
<td>1.75</td>
<td>36.5</td>
<td>41.0</td>
<td>18.0</td>
</tr>
<tr>
<td>KM 17</td>
<td>1330</td>
<td>73.3</td>
<td>2.5</td>
<td>37.5</td>
<td>29.5</td>
<td>17.0</td>
</tr>
<tr>
<td>KM 32</td>
<td>1728</td>
<td>66.5</td>
<td>7.5</td>
<td>28.3</td>
<td>38.8</td>
<td>20.5</td>
</tr>
<tr>
<td>S 87</td>
<td>2272</td>
<td>79.3</td>
<td>1.00</td>
<td>36.5</td>
<td>28.3</td>
<td>13.5</td>
</tr>
<tr>
<td>KM 62</td>
<td>2275</td>
<td>79.0</td>
<td>5.5</td>
<td>33.5</td>
<td>35.0</td>
<td>19.5</td>
</tr>
<tr>
<td>IESV91071LT</td>
<td>2378</td>
<td>73.5</td>
<td>4</td>
<td>45.8</td>
<td>42.8</td>
<td>20</td>
</tr>
<tr>
<td>Kari Mtama 1</td>
<td>2505</td>
<td>73.3</td>
<td>3</td>
<td>36.3</td>
<td>40.8</td>
<td>17.8</td>
</tr>
<tr>
<td>MB 30</td>
<td>2572</td>
<td>77.3</td>
<td>2</td>
<td>36.8</td>
<td>32.5</td>
<td>18.5</td>
</tr>
<tr>
<td>BM 29</td>
<td>2582</td>
<td>77.5</td>
<td>1.75</td>
<td>42.8</td>
<td>35.5</td>
<td>19.0</td>
</tr>
<tr>
<td>E1291 (check)</td>
<td>2795</td>
<td>76.3</td>
<td>1.25</td>
<td>45.3</td>
<td>38.8</td>
<td>18.5</td>
</tr>
</tbody>
</table>
Yield was positively correlated to all the other parameters except days to flowering (Table 3). The less the days to maturity the less the yield. Days to flowering were positively related to plant height and to some extent panicle length, but were negatively related to number of plants, panicle exertion and harvested panicles. Plant height was highly positively related to yield. The taller the sorghum plants, the higher the harvested grain. Less days to flowering also resulted in shorter panicle exertion and fewer number of harvested heads. Number of the panicles harvested was highly positively related to the panicle exertion and stand count.

Table 1. Correlation coefficients estimated among parameters at Naivasha and Laikipia during Mar-May 2015 season

<table>
<thead>
<tr>
<th>Days-50% flowering</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield (kg ha⁻¹)</td>
<td>-0.048</td>
</tr>
<tr>
<td>Plant ht (cm)</td>
<td>0.307 0.603 1</td>
</tr>
<tr>
<td>Plant count</td>
<td>-0.141 0.335 0.133 1</td>
</tr>
<tr>
<td>Panicle exertion</td>
<td>-0.383 0.239 -0.098 0.288 1</td>
</tr>
<tr>
<td>Harvested panicles</td>
<td>-0.359 0.438 0.03 0.609 0.536 1</td>
</tr>
<tr>
<td>Panicle length</td>
<td>0.019 0.232 0.138 -0.115 -0.104 -0.041 1</td>
</tr>
</tbody>
</table>

3.2.1.2 Conclusion

Five genotypes IESV91069LT, NYUNDO, IS-9203, ABALASYA and KM 62, were all found superior in grain yield performance and drought tolerance compared to the checks implying that they were more adapted to the cold dry areas than the rest. All the genotypes tolerated low temperatures at the vegetative stage except IESV91069LT but it was able to out yield the checks even after high scores of low temperature stress indicating high tolerance. The genotypes IESV91071LT, KM 14 and KM 17 which had partial leaf rolling ability and KARI Mtama 1, KM 13 and KM 3 which had stay green trait can be used in future breeding to develop drought tolerant varieties. The genotypes can be used for further breeding to develop higher yielding cold tolerant varieties.

Genotype IESV91071LT, KM 14 and KM 17 had the highest leaf rolling score. KARI-Mtama 1, KM 13, KM 62 and KM 3 had the highest score (4) for stay green. Genotype IESV91069LT had the highest score (4) for frosting. Gadam and KM 14 were partially tolerant to cold temperatures, while the rest of the genotypes were cold tolerant (Table 4).

Stem borer (*Chilo partellus*) was the most observed pest damage (63%) followed by aphids (21%) and in some cases both aphids and stem borer were observed on the same genotype (16%) (Figure 1). The majority of the genotypes were tolerant to diseases, while the most common diseases were blight and rust (Figure 2).

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Leaf rolling</th>
<th>Stay green</th>
<th>Frosting</th>
</tr>
</thead>
<tbody>
<tr>
<td>IESV91069LT</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>NYUNDO</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>IS-9203</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>ABALASYA</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>KM 62</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

L.S.D. = Least Significant difference, C.V. = Coefficient of variation
3.2.1.3 Recommendations
The best performing genotypes IESV91069LT, NYUNDO, IS-9203, ABALASYA and KM 62 could be recommended for variety release.

3.2.2 Evaluation of sorghum elite lines for semi-arid dry low lands of Kenya
Thirty-one advanced open pollinated elite sorghum genotypes bred by KALRO for heat and drought tolerance were planted in the hot dry lowlands of Makueni and Kitui. The treatments were arranged in a randomised complete block design composed with two replications. The plots were 4 m long with 4 rows at a spacing of 75 cm between rows. KARI Mtama 1 and Gadam were used as checks. The trials were carried out for two seasons. Yield data was collected from the two middle rows.

3.2.2.1 Key findings
The average yield was 2492.9 kg ha$^{-1}$ (Table 5). Although 13 genotypes yielded more than KARI Mtama 1 (2225 kg ha$^{-1}$), five genotypes GAM 186 (3900 kg ha$^{-1}$), KM 30-K (4517 kg ha$^{-1}$), KM 32-1 (4796 kg ha$^{-1}$) and KM 32-2 (5251 kg ha$^{-1}$) and GAM 7 (5562 kg ha$^{-1}$) scored the highest in grain yield performance. Among them GAM 7 was the earliest in relation to days to 50% flowering (49 days).

3.2.2.2 Conclusion and recommendations
The five genotypes GAM 186, KM 30-K, KM 32-1, KM 32-2 and GAM 7 were all found superior in grain yield performance, although they were similar to the checks in days to 50% flowering. The five genotypes were advanced to National Performance Trial towards their release.

3.2.3 Farmer criteria in selecting sorghum varieties to grow in lower eastern Kenya: A case study of adoption of sorghum varieties in Makueni County, eastern Kenya
This research was conducted at Kampi ya mawe in Makueni County. Farmer groups from four villages; Kikumini, Muuani, Muusini, and Muvau were identified. A random selection of farmers from each farmer group was done. Fifty-six farmers were selected. Farmers went through a sorghum demonstration plot to observe the different varieties and their characteristics. The trial consisted of released varieties as well as local cultivars. A questionnaire was administered to farmers and their responses recorded on gender, age, education level and marital status. The type of sorghum varieties grown by the farmers was also recorded as well as the preferred season for planting sorghum. Sources of sorghum seeds and the ability to purchase were recorded. The reasons/criteria for selecting and rejecting a sorghum variety to grow were recorded. The selection criteria was measured by the frequency of farmers who used it. The data was analysed following qualitative statistical procedures of the SPSS statistics software version 20 (IBM, 2011).

3.2.3.1 Key findings
Most farmers were females (78.6%) whereby 80.4% were married. The education levels ranged from none (3.6%), primary (58.9%), secondary (32.1%) to tertiary level (5.4%). The ages of the majority of the interviewed farmers was between youth (26-35 years) and adults (36-45 years). All the responded planted sorghum (N=56). The most popular sorghum variety was Seredo planted by 71.4% of the respondents followed by Gadam (64.3%) and then KARI-Mtama 1 (35.7%). Some of the farmers planted local varieties (Kitui and Kateng’u) (Table 6).

Most (69%) of the farmers grew sorghum in both the long and short rain seasons. However some farmers grew sorghum only in the long rains (February to May) and others (20%) during the short rains in October to January.

The farmers sourced seed from grain market (41.1%), own saved seed (35.7%) and official seed markets/seed stockists (12.5%). Of the farmers who bought seed (78.6%), 48.2% of them used their own money and 39.3% used money provided by spouses.
Large grain and high yield ranked highest (51% and 27%, respectively) among the criteria used by farmers to select good sorghum varieties. They also considered resistances to diseases and birds.
Farmers rejected sorghum varieties that showed low yields and small grains sizes. Susceptibility to drought, diseases and birds, late maturity and poor grain filling and grain colour were important attributes in reducing farmer preferences in sorghum varieties.

3.2.3.2 Conclusion

Large grain and high yields are the most important characteristics used by farmers to select in good suitable sorghum varieties. Tolerance to drought and early maturity were also used.

The most planted sorghum cultivars in Makueni County were the improved varieties which included Seredo, Gadam and KARI Mtama 1. Among them, Seredo was the most planted variety.

The farmers bought seed from the grain market and only a few farmers bought certified seed from stockists. Farmers also planted their own seed which can lead to mixing of different varieties resulting in low quality seed.

3.2.3.3 Recommendations

High yielding varieties with large grain is an indicator of the need for a food security variety. Sorghums with this characters may compete with maize as food as well as commercial crop. Future breeding should consider varieties with high yields as well as large grains, drought tolerance and early maturity.

There is need to avail certified seed to farmers with ease. There is also need to train farmers on seed selection and preservation methods in order to maintain quality.

Project Title: Improving Nutritional Security and Livelihoods of Communities in Semi-Arid Regions of Kenya and Uganda Using Multiple Stress Tolerant Sorghum and Legume Cultivars

<table>
<thead>
<tr>
<th>Activities</th>
<th>Achievements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Participatory Evaluation of Research and Farmers’ Sorghum and Legume Varieties in Semi-Arid Kenya</td>
<td>• Farmers selected according to preference from forty-six crop varieties:</td>
</tr>
<tr>
<td>Crop</td>
<td>Preferred varieties</td>
</tr>
<tr>
<td>Beans</td>
<td>Kakunzu, Katumani bean one (KAT B1) and RM – 01 and Katumbuka</td>
</tr>
<tr>
<td>Cow Pea</td>
<td>K80, Kathoka, M66 and KVU 27-1</td>
</tr>
<tr>
<td>dolichos</td>
<td>1002, 1009, Black Dilichos and 1001</td>
</tr>
<tr>
<td>Green Gram</td>
<td>Uncle, No – 26, KAT 00309 and Nylon</td>
</tr>
<tr>
<td>Pepion Peas</td>
<td>Katumani 777/Kionza, KAT Mbaazi-1 (ICPL 8709), and Mbaanzi-2) (ICPL-00040)</td>
</tr>
<tr>
<td>Sorghum</td>
<td>KARI Mtama-1, KARI Mtama-3 (ICSV III), Gadam, Sila</td>
</tr>
</tbody>
</table>

2. Social Economic Survey of Seed Stockists/Companies in Eastern Kenya   | • The main seed companies supplying seed were: Seedoo, Dryland Seed, KALRO Seed Unit, Simlaw Seeds Kenya Seed East Africa Seed, Highland Seed and Pioneer High Bred Kenya |
|                                                                          | • 34 agrovets received the inputs from the 8 seed companies and supplied the farming community                                                                                                           |
|                                                                          | • 29 agrovets were characterized; 15.15% are female and 84.85% are males owned                                                                                                                           |
|                                                                          | • Three companies supply sorghum and legume seed, eight supply only legumes and four others only sorghum                                                                                               |
|                                                                          | • Gadam, Seredo and Serena and Sila are the only varieties traded as certified seed                                                                                                                      |
|                                                                          | • The most popular varieties were: cowpea: KUVU27_1, K80 and M66 Beans: KAT-B1, KAT- B9 and KAT-X56 Green grams: Uncle and Nylon Pigeon peas: ICPL8709_Mbaazi-1 and 00040_Mbaazi-2: Dolichos: KAT-1002 |
3. Farmer fields
Soil quality and fertility testing in Semi-Arid Eastern Sites of Kenya

- The Agrovets/Stockists dwelt in: seed, Fertilizer, fungicides, Insecticide and livestock sprays and animal drugs

- The soils chemical quality results: the soil pH ranged from 6.46 to 7.01 against a recommended range of 5.5 to 7.0. Electro-conductivity ranged from 0.02 to 0.08 against a recommendation of less than 0.15
- The organic matter content: ranged from 0.53 to 0.59 against a recommended range of 1.5 to 3.0%
- The soils physical analysis: soils had high sand content (60-86%), low clay content (12-30%), low silt content (2-14%). The textural grading ranged from Sandy clay loam to Loamy sand

Recommendations: Chemical Properties
- Soil pH: Was suitable for sorghum and legumes at all the sites
- Electrical conductivity: Was suitable for sorghum and legumes at all the sites
- Soil Organic matter: Is extremely low at all sites due to high rate of decomposition as well as low organic matter input. There is need to add in organic matter to enhance plant productivity.
- Total Nitrogen: Low at all sites except Kambu- Kitengei. All farmers should add nitrogen to enhance crop production
- Soil Phosphorus: Low at all sites. Requires P fertilizer application during planting
- Potassium: Adequate at all sites
- Calcium: Low at all sites. It would be important to check plant tissue calcium levels before any recommendations
- Magnesium: Adequate at all sites except, Kambu- Kitengei. It would be important to check plant tissue magnesium levels before any recommendations

4. Assessment of Farmer training needs and training on identified topical areas of interest in eastern Kenya

- Farmers narrowed training needs to: identification of crop varieties choices
- Seed production and use certified seed
- General principle of crop production
- Soil conservation and fertility management
- Soil moisture harvesting and management
- Post harvesting crop handling and management
- And value addition

Table 6: Training venues and farmer holding numbers versus actual number of farmers trained

<table>
<thead>
<tr>
<th>Training Venue /Hall</th>
<th>Training Hall Capacity</th>
<th>Actual Venue /Hall</th>
<th>Number Trained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mukothima social hall</td>
<td>35</td>
<td>Little city conference hall, Mukothimal</td>
<td>30</td>
</tr>
<tr>
<td>Turima Tweru catholic church hall</td>
<td>35</td>
<td>Turima Tweru catholic church hall</td>
<td>33</td>
</tr>
<tr>
<td>Africa inland church (AIC) Syumile</td>
<td>70</td>
<td>Syumile secondary school classroom</td>
<td>67</td>
</tr>
<tr>
<td>Site Type</td>
<td>Column 1</td>
<td>Site Type</td>
<td>Column 2</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>----------</td>
<td>---------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Kitengei Catholic church hall</td>
<td>40</td>
<td>Kitengei Catholic church hall</td>
<td>34</td>
</tr>
<tr>
<td>Mulala Agricultural office</td>
<td>40</td>
<td>Orphaned vulnerable children school</td>
<td>35</td>
</tr>
<tr>
<td>(AIC, Kinguutheni)</td>
<td>35</td>
<td>Kinguutheni catholic church hall</td>
<td>17**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>255</td>
<td></td>
<td>199 (78.0%)</td>
</tr>
</tbody>
</table>
4 Horticulture

4.1 Programme mandate
Horticulture programme Katumani conducts research in fruit trees, both common and local vegetables, as well as alternative crops.

Grain amaranth

Grain amaranth (Amaranthus hypochondriacus) is a relatively new crop in lower eastern Kenya having been introduced into the region by the Kenya Agricultural and Livestock Research Organization (KALRO) Katumani. It is an early maturing, (75-90 days) relatively drought tolerant dual purpose crop providing grains and vegetables. Grain amaranth is nutritious, contains high quality proteins and is rich in amino acid lysine. It contains minerals, oil, vitamins and dietary fibre and is highly digestible making an excellent diet for special needs groups. Grain amaranth is therefore an ideal crop for lower eastern Kenya where high levels of malnutrition have been recorded. The crop was first introduced into the region in 2011 with the support of the Kenya Arid and Semi-Arid lands project funded by the European Union.

- Grain Amaranth Germplasm Evaluation
  Eight elite lines of grain amaranth were evaluated for yield potential, non-loggning and shuttering qualities, drought, disease and pest tolerance in KALRO-Katumani and KALRO-Kiboko sub centres. These lines were KAM 001 (Kisii White), KAM 002 (Kisii Brown), KSC, the Katumani amaranths (KAM 105, KAM 106, KAM 114 and KAM 115) and KAM 201 (red seeded).
- Evaluation of agronomic packages for grain amaranth production
  - The experimental trials were development of agronomic packages on fertility, spacing and water management for grain amaranth production.
  - Efficacy trials on pigweed beetle (Hypolixus haerens Boheman) were carried out and effect control measure identified.
- Evaluation/validation and development of post-harvest technologies
- Product development and recipe formulations
  - Amaranth based recipes were formulated and assessed for acceptability and keeping qualities.
  - Ratios for vulnerable being evaluated in the alboratory
- Identify and fabricate grain amaranth thresher
  - Grain amaranth thresher identified and is being evaluated before being adopted.

Key findings included
Two promising amaranth grain lines, KAM 001 and KAM 114 identified

Preliminary observations have shown that use of 20kg $P_2O_5$ and 10tons of FYM per ha gave higher yields in grain amaranth. It has been established that systemic insecticides can greatly reduce the pigweed beetle menace.

4.2 Achievements
- Two grain amaranth lines entered by KEPHIS in the distinctiveness, uniformity and stability trials.
- Nine hundred kg of grain amaranth seeds multiplied out which 600 distributed to farmers, while the rest were used during trade shows and exhibitions.
- Five farmer groups with 145 members were trained on grain amaranth production and utilization of grain amaranth.
- Participated in the Machakos ASK shows.
- Participated in the Kitui Shows.
- Participated in the Nairobi International Trade Fair.
- Organized and participated in the ASAL APRP field day in Ithookwe, Kitui.
5 Grain legumes

5.1 Programme mandate
The Programme was established in 1999 with the objective of developing well-adapted, high yielding farmer and market preferred varieties of pulses with tolerant to biotic and abiotic stress factors common in Arid and Semi-Arid areas of Kenya. The research focuses on common bean, cowpea, pigeonpea, green gram, dolichos and chickpeas. To achieve its goal, the Programme collaborates with CGIARs centers [International Crop Research Institute for the Semi-arid Tropics (ICRISAT), International Centre for Tropical Agriculture (CIAT), IITA, Asian Vegetable Research and Development Centre (AVRDC)], public universities, ministry of Agriculture, Non-governmental Organization, farmer groups, Seed companies and other KALRO institutes/centers. The main activities of the programme are germplasm collection, characterization, evaluation, selection, variety improvement through making of crosses as well as dissemination of legume based technologies.

5.2 Achievements
5.2.1 Bean breeding
Three bush bean trials comprising 20 micronutrient lines, 12 drought-tolerant lines and 20 heat- and drought-tolerant lines were evaluated in Katumani, Kiboko, Kitui, Maragua and in Laikipia.

Part of the bean trial fields set up at KALRO Katumani_Kiboko, Kitui, Maragua and in Laikipia

Four lines that passed NPT and DUS carried out by KEPHIS were officially released. One variety Nyota is drought tolerant and micronutrient rich. 70 kg of breeder seed was produced and which will be multiplied to breeder stage 2. The other three varieties Angaza, Metameta and Faida are micronutrient rich suitable for medium and high potential areas. 4 kgs of pod to raw nucleus seed per variety was produced. These will be advanced to breeder seed production.
Row seed observation by KEPHIS on breeder seed multiplication of Nyota bean variety

5.2.2 Climbing beans
Sixteen micronutrient rich climbing beans and 12 disease-tolerant varieties were evaluated at Katumani with 3 checks of released varieties. A high iron check from CIAT Uganda was added to the collection.

Part of the climbing bean trial fields set up at Katumani for 16 micro-nutrient rich climbing beans and 12 disease-tolerant varieties

5.2.3 Product formulation and technology dissemination
Twelve released and promising bean lines were evaluated for characteristics relating to cooking time, water absorption capacity, nutritive characteristics and ability to make pre-cooked bean products. The lines that passed the test are KAT B1, KAT B9, Wairimu and Rosecoco. Of these varieties the private sector processing company Lasting Solutions was able to develop three pre-cooked bean products which have been launched for consumers use. These are a bean snack, a bean meal and madodo (a bean flour product).
Pre-cooked bean display rak during the product launch at EKA Hotel Nairobi

The bean meal – no refrigeration required and cooks for 15 minutes
The Cultifl pre-cooked beans project worked with 85 farmers groups in Machakos, Makueni and Homabay Counties in conjunction with Smart logistics and CARITAS Homabay to grow beab grain for the processing industry. The project started with 870 farmers who increased to 1,029. Of this number 266 farmers were growing KATX56 for local marketing which was not preferred by the processor. The remaining 763 farmer (168men and 595women) were growing KAT B1 and KAT B9 preferred by processor. These groups were trained good agricultural practices, gender, food safety, collective production and marketing of bean grains.

Wiga bean production group in Homabay county with KALRO and CARITAS Staff

Another value addition project in the bean sub-program is the BMZ project. The project is working with Nyenji farmers in Limuru County to produce Amaranth leaves and Setawa farmers in Kuresoi for bean production. These groups will sell their leaves and bean grain to AZURI Health limited a processing company. The company is developing bean and amaranth based products for feeding children under five. In part of the farmer capacity building post-harvest issues are critical. In relation to this the two farmer groups were trained in solar bubble driers and supplied with one solatr bubble drier each.
5.2.4 Pigeonpea breeding

5.2.5 Development and release three medium duration large seeded farmer preferred varieties

5.3 Achievements
- Through field evaluations, four medium duration lines (KAT PP08004, KAT PP08005, KAT PP08006 and KAT PP08008) have been identified. The lines are currently undergoing National Performance Trial (NPT) and DUS testing.
- Descriptor development for the new lines underway

5.3.1 Development of segregating early and medium populations that are farmer and market preferred pigeonpea with both cream and speckled/mottled seed

5.4 Achievements
- Preliminary Yield Trial for the new pigeonpea segregating populations for short duration (35 lines) and medium (36 lines) has been established in Kiboko. The F3.4 populations were derived from different crosses [(KARI Mbaazi 1 x GBK 038241), (Mbaazi 1 x MZ 219), (Mbaazi 01 x GBK 038227), (Mbaazi 13 03 x GBK 038241), (KARI Mbaazi 1 x Mbaazi 01 (local collection from Makueni)]. Mbaazi-01 is a large seeded, late maturing line adapted to dry areas of Makueni. MZ 219 is a medium maturing line from ICRISAT and was used due to its resistance to fusarium wilt and large seed size. The progenies were selected under rain fed condition at KALRO-Katumani and Kampi mawe field station during the 2015/2016 cropping season. Data collection and selection on-going.

5.4.1 Dissemination of new improved pigeonpea lines through on-farm demonstration

5.5 Achievements
- Eleven on-farm demonstrations for KAT P08004, KATP08005 and KAT P08006 have been planted in Makueni (Kola, Ukia, Mavive, Itumbule, Kyemole, Muusini, Muvau, Mbooni and Kitui (Molutu). At Itumbule and Muvau, the lines have been intercropped with green gram, at Ukia common bean was used while the remaining farmers used cereals (Sorghum and Maize).
- Dissemination has also been done through NGO (Farmer Input Practice (FIPS) based in Makueni.
- Seed bulking for more promotion is on-going at Kiboko. The seeds will be given to farmers during the short rain 2017/2018 for testing and adoption.

5.5.1 Screening for drought in bean common mosaic virus resistant small red bean genotypes
This trial continued evaluating 16 small red bean lines of Mesoamerican origin for drought, bean common mosaic virus resistance, yield and reaction to diseases in the field and performance under rainfed conditions. The trials were laid in complete 4 x 4 lattice design with 3 replicates. Each line was sown in five, 5 m long rows with an intra and inter-row spacing of 10 cm and 50 cm respectively.

Analysis of variance for mean yield was analyzed using Genstat Version 14.

5.6 Achievements
Drought intensity varied over the 2 seasons. It was most severe during the short rain. Genotypic variation was observed. The overall mean yield was 1918.32 kg/ha and ranged from 323.28 kg/ha (GLP x 92) to 2317.02 kg/ha (SCR 12). The highest yielding genotype SCR 12 had 18% and 45% higher grain yield than lowest yielding genotype SCR 3 and GLP x 92 check variety, respectively. SCR 12, SCR 11, SCR 14, SCR 34 and SCR 7 were the high yielding lines with grain yield of more than two tonne across seasons. SCR 15 had the lowest grain yield. Yield advantage of new lines over the check was 12-45%.
Table 1. Average yield performance of the best five small reds lines during 2016 long rain and short rain seasons at Katumani testing site, Kenya

<table>
<thead>
<tr>
<th>Entry</th>
<th>Vigour</th>
<th>50% DF</th>
<th>BCMV</th>
<th>ALS</th>
<th>50% DM</th>
<th>100 seed mass (g)</th>
<th>Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCR 12</td>
<td>3</td>
<td>38</td>
<td>1</td>
<td>1</td>
<td>79</td>
<td>30.66</td>
<td>2317.02</td>
</tr>
<tr>
<td>SCR 11</td>
<td>3</td>
<td>39</td>
<td>1</td>
<td>1</td>
<td>80</td>
<td>26.43</td>
<td>2209.84</td>
</tr>
<tr>
<td>SCR 14</td>
<td>3</td>
<td>37</td>
<td>1</td>
<td>1</td>
<td>78</td>
<td>29.16</td>
<td>2175.73</td>
</tr>
<tr>
<td>SCR 34</td>
<td>3</td>
<td>40</td>
<td>1</td>
<td>1</td>
<td>82</td>
<td>29.57</td>
<td>2036.55</td>
</tr>
<tr>
<td>SCR 7</td>
<td>3</td>
<td>39</td>
<td>1</td>
<td>1</td>
<td>80</td>
<td>29.14</td>
<td>2018.61</td>
</tr>
<tr>
<td>GLP x 92*</td>
<td>3</td>
<td>35</td>
<td>1</td>
<td>1</td>
<td>77</td>
<td>42.80</td>
<td>323.28</td>
</tr>
<tr>
<td>Average</td>
<td>3</td>
<td>38</td>
<td>1</td>
<td>1</td>
<td>79</td>
<td>28.82</td>
<td>1918.32</td>
</tr>
</tbody>
</table>

*check, BCMV-Bean Common Mosaic Virus and ALS-Angular leaf spot
5.6.1 Greengram

5.6.2 Development and dissemination of early maturing, farmer and market preferred Green gram varieties

Most farmers grow local varieties that are late maturing (90 days) and low yielding. As a result, green gram yields have been decreasing. However, the increase in green gram acreage and production by 76% and 85% respectively in 2014 failed to meet the growing domestic demand of 3,405,000 t. The available commercial variety has small seed size thus not preferred by the market. Use of green gram varieties with genetic tolerance to drought, farmer preferred and marketable grain types is the most effective and efficient strategy of reversing the declining productivity.

5.6.2.1 Objective of the project

- To release three improved early maturing, high yielding farmer acceptable green gram varieties.
- To create awareness to at least 500 smallholder farmers in green gram growing areas in eastern Kenya.
- Develop brochures and publish at least one paper.

5.6.2.2 Progress

- Three improved green gram lines have been identified and officially released in April 2017.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Characteristica</th>
</tr>
</thead>
<tbody>
<tr>
<td>KAT 00301</td>
<td>Early maturity (60-70 days)</td>
</tr>
<tr>
<td></td>
<td>Potential yield range 1800 - 2300 kg/ha</td>
</tr>
<tr>
<td></td>
<td>Large pod size making their harvesting easier</td>
</tr>
<tr>
<td></td>
<td>Large grain size (6-7 g/100 seeds)</td>
</tr>
<tr>
<td></td>
<td>Non-stony seeds</td>
</tr>
<tr>
<td>KAT 00308</td>
<td>Early maturity (65-75 days) compared to local variety (90 days)</td>
</tr>
<tr>
<td></td>
<td>Grain yield range 1800 – 2100 kg/ha</td>
</tr>
<tr>
<td></td>
<td>Large pod size making their harvesting easier</td>
</tr>
<tr>
<td></td>
<td>Large grain size (8-10 g/100 seeds)</td>
</tr>
<tr>
<td></td>
<td>Non-stony seeds</td>
</tr>
<tr>
<td>KAT 00309</td>
<td>Early maturity (65-75 days)</td>
</tr>
<tr>
<td></td>
<td>Grain yield range: 1800 – 2100 kg/ha</td>
</tr>
<tr>
<td></td>
<td>Large pod size making their harvesting easier</td>
</tr>
<tr>
<td></td>
<td>Large grain size (8-10g/100 seeds)</td>
</tr>
<tr>
<td></td>
<td>Grain has shiny green</td>
</tr>
<tr>
<td></td>
<td>Non-stony seeds</td>
</tr>
</tbody>
</table>

- Fifty kilogrammes of breeder seed for each of the three released varieties has been produced. Part of the seed has been given to KALRO Seed Unit for further multiplication and marketing. Further multiplication for large scale dissemination is underway.

5.6.3 Create awareness on new green gram varieties through on-farm demonstrations and field days

5.7 Achievements

- Twenty on-farm demonstrations were conducted in Makueni, Machakos, Kitui and Tharaka together with partners (Anglican Development Services (ADS), Farmer Inputs Practice –FIPS). 349 farmers (143 males and 206 females) participated in the on-farm demonstrations.
- Two farmer field days organized in Makueni and Tharaka in collaboration with partners (Anglican Development Services (ADS) and ICRISAT in Makueni using green gram on-farm demonstrations. A total of 561 farmers (468f; 193m) attended the field day.
6 Kalro Seed Unit

6.1 Programme mandate
The Unit maintains all KARLO pre-released and released varieties, populations and in-breds. This is besides multiplying the breeder, pre-basic, basic and certified seed of the required crop varieties. KSU also propagates seedlings of fruit trees and other vegetative propagated planting materials (stock).

Seed produced in year 2016/17 was 663 tons. The sales were KES 121,254,520.00. Seedlings established were 20,090. The seedling sales totaled KES 14,447 for short of April to June 2017 alone.

Different types of KALRO seedlings and seeds are suited for different parts of the country
7 Natural resource management

4.1 Tillage, cropping system and effect of fertilizer treatment on the grain yields of sorghum and green grams in Kitui County, Kenya

Sorghum and green grams are staple food crops for many low-income households in Kenya. It is typically grown by smallholder, resource-poor farmers mainly for home consumption. Sorghum productivity in semi-arid eastern Kenya has remained low (<0.5 t/ha) even for elite lines with yield potential of 2-5 t/ha. The soils are inherently of low N, available P and organic C and use of organic and inorganic fertilizer in sorghum production could arrest the declining sorghum productivity in ASALs. Therefore, this activity sought to test, validate pre-tested integrated soil fertility and water management (ISFWM) technologies in the productivity of Gadam sorghum and green grams (N 26) with a view to promoting their use in semi-arid Kitui County. Use of 50 % the recommended rate of manure in combination with inorganic fertilizer (HMF- 2.5 T manure + 20 kg N and P ha⁻¹) conferred the highest yield benefit to sorghum and green gram under both sole (Figures below) and intercrop systems. Although tied ridges conferred little yield advantage to both sorghum and green gram relative to flat plant, the current technology of making ridges using oxen as opposed to hand hoe could enhance water availability for crops use and ultimately the productivity relative to flat plant especially in below normal rainfall seasons.

NIL-No fertilizer, FF-40 kg N and P and FM-manure 5 t/ha g
Green gram (left) and sorghum (right) grain yield as affected by soil fertility maintenance practices
8 Outreach and partnership

8.1 Shows
The centre organized and participated in Machakos Agricultural Show of Kenya (MASK) very successfully. Those involved amongst the KALRO Katumani team were our collaborators:-

- Women group who are processing the grain Amaranth – from Muthetheni
- Mango juice processors- from Nzambani- Kitui county and
- KALRO Naivasha- KALRO Kienyenji chicken

About 5350 visited the KALRO Stand at the Machakos ASK Show, including the Centre Director (In coat)
8.2 Field days
Participated in 16 field days, and 2 trade fairs reaching over 7,442 stake holders in four counties Machakos, Makueni, Kitui and Kajiado.

8.3 Visitors
The Centre was visited by a total of 4299 people that included students, farmers, policymakers and other stakeholders.

8.4 Workshops/meetings
During the year 6 workshops were held as follows:
- Training workshop on Agricultural Sector Development Support programme (ASDSP) Data Tools-at Kibwezi Guest view hotel- Kibwezi
- Makueni County Steering Committee workshop- Kamp David Hotel –Makindu
- Three Stake holder Workshop –Machakos
- Three Agricultural Value Chain Platform workshops – Machakos, Makueni and Kajiado
- 10- County Steering stakeholder- 3 Machakos and 4 in Makueni and 3 Kajiado

8.5 Value chain meetings
- 2 Local chicken value Chain meetings- MAP board room Wote
- 2 Mango Value chain meetings- MAP board room Wote
- 3 Green gram value chain meetings – at MAP board room Makueni

8.6 Demonstration
One demonstration plot at the centre in which all the student visitors and most of the visitors are taken through.

8.7 Exhibitions
- One exhibition held at Isinya Kajiado-52 Exhibitors displayed and Over 3,000 people attended.
9 Oil and Industrial Crops

The Oil and Industrial Crops Program at KALRO-Katumani works closely with the Crops Industrial Institute of Mtwapa. At AMRI Katumani the program evaluates oil and other related crops for their suitability and adaptability within the arid and semi-arid lands of eastern Kenya.

1.2 Key findings

1.3 Effect of pollen beetle pest to pollinator bees on sunflower, in eastern Kenya

Effect of pollen pest beetles to the pollinator bees on sunflower head was comparatively studied at KALRO-Katumani field plots, during the production years of 2014-2016. The amount of rainfall recorded in 2014 was 397 mm, 734 mm in 2015 and 226 mm in 2016. Counts of each insect species of beetle and pollinator bee were scored and the results analyzed alongside amount of rainfall.

The population of pollinator bees decreased with increasing drought. It was also observed that the population of pollen beetles increased with increasing drought as indicated by different rainfall shown in Figure 1. Low sunflower yield was observed during drought periods. The main contributor to the low yield was a low population of pollinator bees. This was indicated by poor sunflower seed-set especially towards the central part of sunflower head. In some cases, there was total absence of kernels on the sunflower head due to lack of pollination.
Fig. 1. Pollen-feeding beetles effect to pollinator bees
10 Root and tubers

10.1 Sweetpotato
Sweetpotato is one of the most important staple food crops consumed in Kenya. It plays a significant role not only as a food security crop but also as a potential commercial and subsistence crop. Its production in Kenya is 9.53 t/ha which falls way below the expected maximum yield potential of 50 t/ha\(^1\). This is mainly due to biotic factors which include pests (sweetpotato weevil, weeds, nematodes) and diseases (virus, alternaria blight, bacterial wilt, fusarium wilt), abiotic factors (water stress, soil nutrition deficiencies and floods) and socioeconomic factors mainly lack of appropriate varieties, clean seeds, poor utilization and marketing. Dissemination of sweetpotato technologies that improve production was carried.

10.2 Achievements
Various varieties were screened for disease and pests tolerance

Fig. 1. (a) Sweetpotato crop in the field and (b) orange fleshted tubers

The developed technologies being disseminated were as follows

10.2.1.1 Fertilizer use demonstrations
Fertilizer NPK (18:18:0) was applied at planting at the rate of 5 g per hill to demonstrate that use of fertilizer increased the yield on the varieties compared to Non fertilizer trials.

Effect of fertilizer on sweetpotato yields at different sites

The results indicated that use of fertiliser had significant increase in yield on varieties on different sites, which resulted to higher yields and income. Alos variety Kabode responded better to fertilizer addition.
10.2.1.2 Planting density demonstrations
The spacing 60x30 and 90 x30= 2.3: 1/5 variations were used in this demonstrations to demonstrate that in sweetpotato high density increases root yield.

Effect of plant density on sweetpotato tuber yields

It was demonstrated that use of higher planting density resulted to significant increase in yield on varieties on different sites and therefore also led to increased income.

10.2.1.3 Dissemination of weed control methods
Weed control using poly ethane cover, twice and hand weeding was also demonstrated to demonstrate that Poly ethane cover effectively controlled the weeds and resulted to high yield. It also helped preserve soil moisture, and controlled weevil infestation.

This demo showed that Use of PE Mulch significant increase yield on varieties on different sites, which resulted to higher yield and also income.

10.2.1.4 Virus free seed production system
Demonstrations on net tunnels for keeping planting materials clean were also done to train farmers on keeping their seed clean onfarm.

Effect of clean seed on sweetpotato tuber yield
10.2.1.5 Kiboko and KALRO Katumani, clean seed bulking
Clean seed multiplication was planted at Kiboko and KALRO Katumani in order to secure seeds for planting in the next demo plots. The seed multiplication is progressing on well. This will serve as source of clean seed for the long rains demo plantings.

Plate 2. Seed bulking and seed distribution

10.2.1.6 Virus free seed production system
Clean sweet potato plant materials are developed using tissue culture technology in the lab. These plantlets are hardened and then planted in net tunnels or screen houses to protect them from virus infections. In this case net tunnel technology is being promoted under this project in order to keep stock plants clean at on farm level. Farmers were trained on construction of low cost net tunnel for preserving the sweetpotato planting materials clean.

Plate. 3. Net tunnel being constructed at the backyard garden in Zambezi

10.2.1.7 Development of high yielding virus resistant and high beta carotene sweetpotato varieties through breeding
Four lowland virus tolerant and or drought tolerant high yielding varieties and three checks identified as (DELVIA, IRINE, KABODE (check), NUSPOT 12, SPKO31 (check), SUMAIA and VITAA (check)), were evaluated at the National Performance Trial in Siaya, Alupe, Kakamega, Katumani, Kiboko and Embu in Kenya. Data was collected and analysed.

A summary table of the analysed data is shown below. Naspot 12 and Sumaia performed relatively better across the traits.
10.3 Cassava

10.3.1 Cassava breeding activities for the quarter ending 30th June 2017

Plate 4. Young cassava crop (b) mature harvested roots

10.3.1.1 Advanced yield trial

Fifteen cassava varieties which included five local checks were planted in advanced yield trials at Kiboko and KALRO Kandara in 2015/16 planting season. Among these were Thika2, Thika6, 92/00061, TME419, TC2, Thika5, TC4, TC14, TC17, TC19, Wakahi3, Kileleshwa, Wakahi4 and 990005. They were planted in a five row plots of ten plants per row with three replications at spacing of one metre between rows and between plants. Data from the three middle rows was taken and recorded on percentage plant establishment; plant/branching heights and pest/disease reaction. The results are shown below (Table 1). Clone 92/00061 had the highest establishment (91.1%) while T44 had the lowest (37.8). The means for establishment, branching and plant height were 75.0, 64.1 and 33.3 respectively (Table 1).

Clones TC2, 990005, TC4, TC14 AND 92/00061 showed resistance to cassava mosaic disease while Thika2 and Kileleshwa had the highest susceptibility.

Clones TC4, 92/00061, TME419 and TC14 did not show symptoms of cassava brown streak disease. This is an indication that these clones could be resistant to the disease.

Varieties 990005, 990132 and 990127 had the highest yield 41.0, 38.2 and 39.4 respectively. They yielded even much higher than the highest performing checks (Shibe and Karembo) which had yields of 28.6 and 25.3 respectively. Variety 08/0011 had the starch content of 20.3 much higher than the checks however it did not perform as well in terms of yield.

These three varieties have been released and were given local names as Katsuhanzala (990132) Katune (990005) and Kasukari (990127). As anticipated the HCNP level were low in all the varieties and this could have attributed by the fact that these have gone through rigorous stages of selection.
11 Maize

11.1 Programme mandate
The Programme seeks to assemble and evaluate maize germplasm, and develop varieties that are resistant to abiotic (drought, heat, and edaphic factors) and biotic factors (stem borers, weevils, LGB, aphids, maize streak, head smuts, etc) stresses of the ASAL areas. The programme also develops sustainable maize husbandry (agronomic) technologies that maximise yields at both low and optimal input levels.

11.2 Achievements
12 Socioeconomics and applied statistics

12.1 Achievements

12.1.1 Determinants of Household Income from Crop Sales: The Case of Common Bean Production and Marketing in Selected Bean Corridors in Kenya

A study was carried out to characterize common bean producers, bean marketing challenges and potential opportunities that can be explored for increased adoption and production of common beans along selected bean production corridors in Kenya. This paper explores both the challenges and emerging opportunities from analysed survey data of 440 respondents selected using a multi-stage random sampling procedure. Study findings show that labour distribution across bean production activities were predominantly carried out by male and female household members. Over 86% of male respondents did most of land preparation – could possibly imply a major challenge for female-headed households. Bean sorting was done mostly (91%) by women. Up to 50% of the respondents said crop farming was their main source of household income. Farmers with secondary and above level of education stood to significantly gained more from crop sales relative to those with either primary of no education at all ($p=0.04$). Use of certified bean to plant coupled with large portion of owned land set aside for bean had great potential to positively contribute to household income from crop sales ($p=0.07$; $p=0.028$ respectively). Challenges associated with bean marketing were low prices, transport - trekking for long distances to sell farm produce and procure farm inputs and market intermediaries interfering with market price stability. Value-addition of beans at industrial level can enhance both household income and nutrition.

12.1.2 Influence of multi-stakeholder linkages and practices on technology and innovation adoption among smallholder farmers in semi-arid lower eastern Kenya

A study involving 165 households in Kitui, Machakos and Makueni Counties was carried out to establish how the existing linkages between research, policy and practice affected technology and innovation adoption among smallholder farmers. Understanding the effectiveness of the existing linkages and its implications for enhanced technology and innovation adoption for improved farm productivity, hence food security in the region was crucial. Using Face-to-Face household interviews in six Sub-Counties where past public-private-partnership development initiatives have been implemented. Specifically, the study focused on commercialization of Gadam sorghum. The interviews focused on the respondent’s rating on the existing linkages on development implementers’ level of feedback to farmers; level of teamwork between the development implementers and the farmers; level of technology and innovation adoption; and, project planning and implementation. Data were analysed based on four study variables developed as statements relating to specific action as viewed by the individual respondent on a five-point Likert type scale rating. Study findings revealed that farmer’s adoption of technology and innovation in growing Gadam sorghum was significantly and positively influenced by information sharing ($\beta=0.396$, $t =8.141$, $p <.05$), prevailing policies ($\beta=0.364$, $t = 6.777$, $p<.05$), competition among the stakeholders ($\beta=0.284$, $t = 6.297$, $p<.05$) and independent farmers attitudes ($\beta=0.065$, $t = 1.271$, $p<.05$). Information sharing is important in enhancing technology adoption. Openness and trust in information sharing were crucial in maintaining strong linkages between different development partners. Strong linkages between research, policy and practice were necessary to enhance technology development, promotion and adoption. Existing linkages should be clearly defined for proper coordination of information sharing, information flow and feedback. Public-private-partnerships enhance sustainable development in developing countries. Thus, information generated from this study is of interest for policy makers and development partners for establishing strategies to achieve strong linkages between research, policy and practice.

12.1.3 The status of agricultural mechanization in Kenya: The case of maize in Trans-Nzoia County

Agricultural mechanization is low in Kenya and yet there have been several efforts by the government, voluntary and non-organizations (NGOs) to promote it since independence. The low agricultural productivity has been associated with numerous factors, one of them being low levels of mechanization.
The goal of this study was to contribute to the understanding of the agricultural mechanization systems among selected value chains for purposes of recommending research and policy interventions in Kenya and beyond. The study was undertaken on major agricultural value chains in Kenya. It focused on value chains of highest economic importance in Kenya, viz, food crops; (maize, rice and wheat) industrial crops; (tea, sugarcane and coffee), horticultural crops; (tomatoes and mangoes) and livestock (cattle, dairy, sheep/goats, and poultry). The study had five main objectives including appraising the status of information on agricultural mechanization in Kenya, establishing the levels of agricultural mechanization among selected agricultural value chains, identifying constraints and proposing interventions for the adoption of the improved agricultural mechanization technologies and innovations, recommend strategy and research agenda and make technical and policy recommendations to enhance agricultural mechanization in the respective value chains in Kenya.

Data collection was done at different levels that included secondary sources, Key informant interviews and use of the semi-structured questionnaires for the selected agricultural value chain. This was undertaken in three phases, with the first phase involved in collecting secondary information and desktop reviews through key informants’ interviews via taking notes, use of checklists and discussions. The focus was on development partners, relevant research institutions, universities, agro-dealers, headquarters and county ministry of agriculture. The second phase involved developing and finalizing the interview tools that included questionnaire development and pretesting as well as recruitment and training of enumerators. The third and final phase was the actual implementation of the questionnaire in the selected counties. The questionnaires were administered to the respondents by trained enumerators particularly on their farms where coordinates and elevations were determined using global positioning system (GPS) equipment. The survey was undertaken using a multistage sampling design which included, selecting the nine value chains, the counties, sub counties and wards or production zones and finally random sample of respondents using transects depending on the nature of the value chain. The study considered the value chains in terms of the enterprise sizes, viz small, medium and large scale. A total of 60 respondents were interviewed in Trans Nzoia County on maize and livestock.

In the food crops system (maize) mechanization for land preparation was relatively high with the lowest being 67% and the highest being 100%. Ploughing was mostly done by oxen and four wheeled tractors using, implements such as ox plough, disc plough and mouldboard depending on the soil type. Where harrowing is done disc harrow is used, while for rotavation motorized rotavator is used. In terms of ownership the machinery used is either owned on hired. Mechanization for planting was practiced with 56% respondents using planters. The machinery used in planting was the tractor drawn planters which were either owned or hired while level of mechanization in weeding was 46%. Harvesting was mainly done using manually while transportation was highly mechanized and the mode used was Ox/donkey carts, tractor trailers and three wheeler vehicles.

The major constraint identified that were impacting negatively on agricultural mechanization were as follows:

- Unavailability of machinery services
- Lack of finance to acquire machinery
- High cost of machinery and equipment for crops and livestock management
- Small farm holdings are fragmented, and therefore machinery cannot be used.
- Inadequate information on agricultural mechanization
- Lack of skills on agricultural machinery
- No commercialization strategy for agricultural mechanization innovations
- Poor access roads in the rural areas

12.1.4 The status of agricultural mechanization in Kenya: The case of mangoes in Makueni County

Agricultural mechanization is low in Kenya and yet there have been several efforts by the government, voluntary and non-organizations (NGOs) to promote it since independence. The low agricultural productivity has been associated with numerous factors, one of them being low levels of mechanization.
The goal of this study was to contribute to the understanding of the agricultural mechanization systems among selected value chains for purposes of recommending research and policy interventions in Kenya and beyond. The study was undertaken on major agricultural value chains in Kenya. It focused on value chains of highest economic importance in Kenya that included horticultural crops; (tomatoes and mangoes) and livestock (cattle, dairy, sheep/goats, and poultry). The study had five main objectives including appraising the status of information on agricultural mechanization in Kenya, establishing the levels of agricultural mechanization among selected agricultural value chains, identifying constraints and proposing interventions for the adoption of the improved agricultural mechanization technologies and innovations, recommend strategy and research agenda and make technical and policy recommendations to enhance agricultural mechanization in the respective value chains in Kenya.

Data collection was done at different levels that included secondary sources, Key informant interviews and use of the semi-structured questionnaires for the selected agricultural value chain. This was undertaken in three phases, with the first phase involved in collecting secondary information and desktop reviews through key informants’ interviews via taking notes, use of checklists and discussions. The second phase involved developing and finalizing the interview tools that included questionnaire development and pretesting as well as recruitment and training of enumerators. The third and final phase was the actual implementation of the questionnaire. The questionnaires were administered to the respondents by trained enumerators particularly on their farms where coordinates and elevations were determined using global positioning system (GPS) equipment. The sampling was done using a multistage sampling design which included, selecting the value chains, the counties, sub counties and wards or production zones and finally random sample of respondents using transects depending on the nature of the value chain. The study considered the value chains in terms of the enterprise sizes, viz small, medium and large scale. A total of 60 respondents were interviewed in Makueni County on mangoes and livestock.

Land preparation is one of the key operations required for a proper seed bed establishment for all the crops. The level of mechanization in the horticultural crops including mangoes ranged from 81 to 96% of the sample farmers. Ploughing was mostly done by oxen and four wheeled tractors using, implements such as ox plough, disc plough and mouldboard depending on the soil type. Level of mechanization in planting was nil while in weeding it was less than 5%. There was very little (less than 5%) of mechanization in harvesting mangoes. The machinery used in transportation of industrial crops and horticultural crops were wheel barrow and motor vehicle which was either owned and or hired. There was no significant value addition for horticultural crops amongst the farmers interviewed. Value addition, although given prominence in Kenya there is little effort in its promotion as is evident on the value chains studied. There is great opportunity in this activity which requires availing and promotion of the relevant machinery, especially for industrial and horticultural crops.

This study considered mechanization for livestock which included cattle, poultry, sheep and goats. In this category mechanization was relatively low. In the horticultural livestock interaction crop system’s highest mechanization level was reported in manure handling (33.3%). Similarly, modest mechanization was reported in chaff cutting and milk transportation. There was no mechanization reported for poultry management, milking, and forage production in this system. In conclusion it was noted that the livestock mechanization was required in feeding, deworming, animal protection, milking and slaughtering. As well, there was no value addition reported and hence providing an opportunity for increased productivity, value addition and income through mechanization.

The study identified major constraints impacting on agricultural mechanization as follows;

- Unavailability of machinery services
- Lack of finance to acquire machinery
- High cost of machinery and equipment for crops and livestock management
- Small farm holdings are fragmented, and therefore machinery cannot be used.
- Inadequate information on agricultural information
- Lack of skills on agricultural machinery
- No commercialization strategy for agricultural mechanization innovations
- No agricultural mechanization testing/inspection unit for machinery
- Uncoordinated research on agricultural mechanization
- Poor access roads to the farmer fields
13 Human Resource Management Administration

The functions of Human Resource Management Administration entail making recommendations to the Authorized Officer regarding:

- (i) Recruitment, selection and appointment;
- (ii) Performance management;
- (iii) Promotions;
- (iv) Confirmation in appointment;
- (v) Training and Development;
- (vi) Training Impact Assessment;
- (vii) Management of skills inventory;
- (viii) Establishment and Complement control;
- (ix) Payroll management;
- (x) Deployment;
- (xi) Promotion of values and Principles of Public Service;
- (xii) Recommendation for secondments and unpaid leave;
- (xiii) Recommendation for retirement;
- (xiv) Recommendation for retirement on medical grounds;
- (xv) Recommendation for re-designation;
- (xvi) Recommendation for renewal of contract;
- (xvii) Discipline;
- (xviii) Pension administration, employee counselling and guidance a most other areas.

STAFF TURNOVER 2016/2017

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- The total number of employees who retired/exited in the year 2016/2017 was 23
- The total number of employee who completed MSC in the year 2016/2017 was one
- The total number of employee who completed PHD in the year 2016/2017 was one
- The total number of students on attachment in the year 2016/2017 was 39
- The total number of visiting students in the year 2016/2017 was 762
Publications

13.1 Journal papers


13.2 Brochures


13.3 Manuals


13.4 Technical bulletins
Grain amaranth: An answer to food insecurity and malnutrition in the arid and semi-arid lands of Kenya - Case study of Utithini women orphan child care group

13.5 Posters
Early sorghum grain harvests to deter bird grain damage. www.kalro.org/asal-aprp/docs/Poster_birds control on sorghum.pdf
Strategy for control of bollworm for sustainable sorghum crop under varied regimes of rainfall, temperature and soil fertility www.kalro.org/asal-aprp/docs/strategy for control of bollworm for sustainable sorghum crop.pdf

Evaluation of elite lines of grain amaranth (Amaranthus hypochondriacus) in Semi-arid eastern Kenya

13.6 Human-face stories
13.6.1 Farmers field days
KALRO scientists work with Farmers to select crop varieties suitable for...
www.kalro.org/asal-aprp/node/142

Rachael Kisilu (Pictures by John Ayemba) KALRO-Katumani. Matching promising crop varieties to suitable agro ecological and socioeconomic contexts should ...

The ASAL-APRP implementation committee reviews Project progress...
www.kalro.org/asal-aprp/katumani_pic

Reported by John Ayemba and Rachael Kisilu (KALRO-Katumani). Reviewed by Rahab Muinga, Knowledge and Information (KALRO-HQ). The Arid and ...

ASAL-APRP reviews its activities with farmers’ groups and partners...
www.kalro.org/asal-aprp/m%26e%20katumani

Reported by John Ayemba and Rachael Kisilu (KALRO-Katumani) Reviewed by Rahab Muinga, Knowledge and Information (KALRO-HQ).

KALRO/ASAL APRP Project in collaboration with MoAL&F showcase...
www.kalro.org/asal-aprp/MoAL%26F%20showcase

Reported by Rachael Kisilu and John Ayemba (KALRO-Katumani) Reviewed by Rahab Muinga, Knowledge and Information (KALRO-HQ). KALRO-Katumani

KALRO-Katumani improving sorghum productivity in arid and semi-arid lands. Reported by Kamene Kisilu and Luvai Mutisya, Photograph by Atabachi Ayemba http://www.kalro.org/asal-aprp/node/147
KALRO/ASAL APRP Project in collaboration with MoAL&F showcase dry land crop technologies for increased food productivity in Kitui County. Reported by Rachael Kisilu and John Ayemba (KALRO-Katumani) (Reviewed by Rahab Muinga, Knowledge and Information (KALRO-HQ))

13.6.2 Agricultural shows
KALRO-Katumani excels at the Machakos southeastern ASK show. Reported by Rachael Kisilu, Miriam Mutua, Eduardo Kilonzo, Cherani Ariithi and Malo Nzioka (Photos by Atabachi Ayemba) KALRO-Katumani http://www.kalro.org/asal-aprp/node/146

13.6.3 Conferences and exhibitions
Katumani wins awards at ASAL-APRP End of Project Conference. Reported by Rachael Kisilu and John Ayemba (KALRO-Katumani) (Reviewed by Rahab Muinga, Knowledge and Information (KALRO-HQ))

13.6.4 Radio broadcast
A radio advert made in Kikamba to reach wider audience in the lower eastern Kenya

I greet you and welcome you to our today’s presentation on our farming segment, which presents benefits and wealth in farming. Today I am with an expert in agricultural research from KALRO who will explain to us how they collaborate with farmers in their farming. My name is Peter wa Tatu. Welcome to our programme and explain to us how KALRO works. Welcome! My Name is Rachael Kisilu. I work with agricultural research organization called KALRO. I am based at KALRO-Katumani where we research on appropriate seed technologies which farmers are supposed to plant especially in arid and semi-arid lands. In KALRO-Katumani, I am involved in research on varieties like sorghum, maize, cowpea and greengram, and especially on sorghum and in KALRO-Katumani we have been funded by the project called ASAL-APRP which has been funding us to help develop the appropriate dryland farming technologies. The project is promoting dryland farming and encouraging farmers to grow drought-tolerant crops because the rainfall patterns have changed and the amounts have reduced. We encourage farmers to grown the crops that were grown in old days in line with the available rainfall amount. KALRO stands for the Kenya Agricultural and Livestock Research Organisation comprising of 16 research institutes, one of which is AMRI (Agricultural Mechanisation Research Institute) based at Katumani, Machakos. AMRI is charged with the responsibility of developing machines that may make farming activities easy, especially for large scale productivity. Such include machines that would reduce labour during land preparation, weeding, harvesting and processing for value addition. KALRO-Katumani has enough stocks of seed of improved crop varieties and recommended agronomic practices suited for the ASALs. KALRO uses various ways to disseminate available technologies to its clients. Among the methods used are field days, farm demonstrations and agricultural shows. We encourage farmers to visit and get advice on the available agricultural mechanization technologies suited for their farming environments for improved farm productivity.