The Horticulture programme at AMRI Katumani conducts research in fruit trees, both common and local vegetables, as well as aromatic and medicinal plants (MAPs). The programme research is towards increased vegetable, fruit and medicinal and aromatic plants options which sustainably could be established in marginal lands of Kenya.

Constraints to horticultural production
The major constraints to horticultural production are;

i) Inappropriate crop varieties, farmers tend to try any crop materials even though they may not be suited for the region.

ii) Infestation by major pests and diseases leading to low quality produce that are unmarketable and reduced yields. This translates to loss of income by the farmer and the country.

iii) High post-harvest losses due to bulkiness and short shelf-life associated with horticultural produce which consequently results into glut and low market prices.

Objectives

iv) To identify superior varieties of fruits, vegetables, aromatic and medicinal plants (MAPs) that are tolerant to drought, major pests and diseases, early maturing, high yielding, with good shelf life and consumer acceptability.

v) To develop, validate and promote appropriate environmentally friendly IPM/ICM packages for target horticultural crop

vi) To develop, validate and promote suitable harvest and post harvest handling packages for horticultural crops.

Vegetable research
The horticulture programm at Katumani undertakes research on both common, African leafy vegetables and grain amaranth. Vegetables are very nutritious being rich in micronutrients (minerals and vitamins), proteins and dietary fibre while some have medicinal properties. Several varieties of amaranth have been developed and have been to KEPHIS for registration.
1. **Amaranth species (grain and vegetable)**

Grain amaranth has multiple uses as a vegetable, nutrient-rich grains and livestock feed. Amaranth grain is highly nutritious and contains 16-20% protein, 5-10% oil, minerals, vitamins, trace elements and dietary fibre. It is particularly rich in the amino acid lysine which is low in cereals like maize and wheat. Nutritive values of cereals are enriched when blended with amaranth. Cooked grain is up to 90% digestible and an excellent weaning diet, recommended for the elderly and people who have been through a long fast or starvation. Being an immune booster it is good for those living with HIV/AIDS and severely malnourished people.

Amaranth leaves are high in vitamins A, K, B₆, C, riboflavin and folate; and essential minerals including calcium, iron, magnesium, phosphorus, potassium, zinc, copper, and manganese. The vegetables are very rich in iron and therefore good for anaemic people. They are high in vitamin A and one hundred (100) grams of vegetables cooked without oil can contribute up to 45% of the daily vitamin A requirement.

It is early maturing (75-90 days) and the leaves ready in three weeks after planting. Grain amaranth drought tolerant suitable for a wide range of agroclimatic conditions. Can grow in a wide range of environmental conditions between 0 and 2,400 m. Does well in well-drained high organic matter content, shallow, stony, crusty clay soils.

Grain amaranth varieties developed at KALRO Katumani

i. **Katumani Amaranth (KAM) 001**

- The stem is green with a light purplish base
• It has broad green leaves
• The plant bears several panicles on each branch
• The panicle is open, green and turns to yellowish-green and then light golden when mature
• Very small seeds (1,000 seeds weigh 0.6-1.2 grams)
• The seeds are golden in colour
• Yield potential in the ASALs is 500 kg grain and 400 kg leaves per hectare

ii. Katumani Amaranth (KAM) 114

• The stem is green with a light purplish base
• It has broad green leaves
• The plant bears several panicles on each branch
• The panicle is open, green and turns to yellowish-green and then light golden when mature
• Very small seeds (1,000 seeds weigh 0.6-1.2 grams)
• The seeds are golden in colour
• Yield potential in ASALs is 500 kg grain and 400 kg leaves per acre

iii. Katumani Amaranth (KAM) 201
This variety has similar attributes as KAM 114 except that the seeds are redish-brown

iv. Katumani vegetable amaranth

- The plant is bushy
- Grows up to 1.5 m in height
- Stem is green
- Green leaves with a purple tinge
- The petioles are pinkish purple
- Very small seeds (1,000 seeds weigh 0.6-1.2 grams)
- The seeds are black in colour
- Yield potential in the ASALs is 600 kg (fresh) leaves per hectare

2. Postharvest technologies validated and/or developed

i. Drying as food preservation technique

Drying is a preservation method whose objective is to increase the shelf life of highly perishable produce like fruits, vegetables, cereals and meats. This is achieved by reducing moisture content of fresh produce through direct sun drying, solar drying and freeze drying. The moisture content of the produce is reduced to about 10% and extends the shelf life of produce by about six months. Drying greatly reduces the volume
of the produce making packing, storage and transportation much easier.

Amaranth Uses
Amaranth vegetables are used in salads, sauces and stews while the stem and older leaves can be used as livestock feed. The whole grains are boiled, roasted or popped or eaten as sprouts. The grain may milled into flour, blended with wheat flour to enable it to rise and used in the baking and confectionery industry. Amaranth and wheat
flours blended at different ratios can be used to make chapatti (flat bread), mandazi, doughnuts, cakes and pancakes at home. Amaranth flour can be blended with maize. Grain amaranth is a relatively new crop in the region and many people do not know how to utilize it. Several recipes have been developed and are highly acceptable.

ii. Recipes developed

Assorted amaranth products
Agronomic requirements

3. Land Preparation

Grain amaranth is a very small seeded crop and therefore requires a fine seedbed. For virgin land, oxen or tractor ploughing followed by harrowing is recommended. For cultivated land harrowing is necessary.

![Land preparation by oxen-drawn plough](image1)
![Ploughed land](image2)

After harrowing soil clods should be broken and the field levelled to suit the size of the seeds.

![Levelling of land in readiness for planting amaranth](image3)
![Properly levelled land](image4)

Planting and Seed Rate

Planting should be done at the onset of the rains. Make shallow furrows spaced at 75-90 cm apart. Amaranth may also be planted under irrigation.
Amaranth does well in fertile soils with high organic matter content. Apply well decomposed farm yard manure (FYM) at the rate of 10 tons per hectare. Thoroughly mix the FYM with soil using a stick. Using DAP at a rate of 20 kg P₂O₅ per hectare gives reasonably higher yield when there is adequate soil moisture. Compost manure can also be used.

A seed rate of about 1 kg per acre is recommended. Mix grain amaranth seeds with dry sand or soil at the ratio of 1: 10-20 (1-part seed to 10-20 parts sand or soil) to avoid wastage.
Drill the seed mixture evenly and thinly in the already prepared furrows at a depth of 5 cm. The seed-soil mixture can also be planted along the rows at a spacing of 30 cm apart.

Cover the seed lightly with soil using a stick. The seeds possess an aroma that attracts ants and therefore should be covered immediately after sowing to avoid being carried away by ants. Amaranth requires adequate moist conditions for establishment. When there is adequate moisture in the soil, seeds germinate 3-4 days after sowing. Once the crop is established it is relatively drought tolerant.

**Seed Production**

Amaranth is a cross pollinated crop and hybridization occurs between species. When planting amaranth for production of seeds an isolation distance of 400 meters should be maintained to avoid seed contamination. Off types should be uprooted regularly.
Weeding
Initially amaranth grows very slowly making it susceptible to competition from weeds. Weeding is crucial at this initial stage until the crop is well established. Keep the crop free from weeds by weeding with hoe, oxen or by uprooting. More than 90% of the crop can be lost due to weed competition in the early stages before proper plant establishment.

Weeding may be done 3-4 times during the growing season until the crop forms its own canopy and is able to smoother weeds. Keep the field free of weeds by weeding or uprooting weeds.
Water harvesting structures such as ridges can be constructed at weeding to aid in moisture conservation during seasons when rainfall is below average. When the plants are about 30cm high earth up soil around plants to avoid lodging. This also helps reduces competition from weeds.

2.1.2 Thinning
First thinning should be done after the crop has attained a height of about 10cm. Uproot weak and malformed plants and leave the strong and robust ones. The first thinning is done to reduce the plant population and lower completion, encourage aeration and light penetration. Subsequent thinning should be done until the onset of heading, leaving one plant at an intra-row spacing of 30 cm apart. Thinning can be used as vegetables or fed to livestock.

Surveillance from early growth
When the plants have attained six to ten leaves (approximately one month old) visit the field and scout for presence of windowing or mining symptoms on the leaves (Fig. 2.3.1). These could be bollworms or leaf miners. These insects reduce the photosynthetic area of the leaf tissue, leading to reduced leaf or grain depending on the variety. Little disease symptoms occur at vegetative growth.
Tending to young amaranth

Windowed leaves

Early scouting for pests

**Control of pests at vegetative stage**

A spray of Bulldock Star® 262.5 EC (pyrethroid-organophosphate) or Beta-cyfluthrin 12.5g/litre twice at intervals of two weeks is crucial for elimination of leaf miners, leaf defoliators and pigweed beetle. Other emerging insecticides can also be assessed as need may arise.

Pigweed beetle damage on stem

Early spray prevents damage

Pigweed beetle stem damage and subsequent insecticide spray

**Monitor amaranth fields regularly**

There is need to regularly scout the amaranth field to make sure the plants continue to develop without any attack of pest and diseases. Most pests and disease occur at the flower bud stage. (Fig. 3.1).
Seed Processing
Place the harvested panicles on a clean tarpaulin under the sun. Thresh the panicles by hitting lightly with a stick while turning them to ensure that all seeds are released. After harvesting the panicles may be threshed by use an amaranth thresher. Separate the waste from the grain. Winnow and dry the seeds under the sun to 10-12% moisture content and avoid microbial growth. Waste from threshing can be fed to livestock or used for mulching.
Impurities lower seed quality. Ensure that seeds are not contaminated with sand or soil particles right from harvesting through processing to storage. Put dried seed in gunny bags and store in a cool dry place. Properly dried and well stored seeds can keep for up to 2 years without deteriorating. Amaranth seeds may remain viable for up to 5 years if 5% moisture content is obtained.

Publications
Title: Amaranth pigweed beetle damage level correlates to environmental temperature regimes
Daniel L. Mutisya, Fatuma O. Ghelle and Emerita Njiru

Title: Targeting appropriate Grain Amaranth production technologies for improved productivity, household nutrition and income security in semi-arid eastern Kenya
Emerita N. Njiru, Fatuma O. Ghelle and Daniel L. Mutisya

These papers were during the 1st Chuka University International Conference

Poster Yield and nutritional potential of grain amaranth (Amaranthus hypochondrius) in lower eastern Kenya.
Poster presented during the 3rd Chuka International conference
Fatuma O. Ghelle, Emerita Njiru, Daniel L. Mutisya, M. M. Karoki and D. M. Mwangi

Amaranth grain yield response to inter-row spacing and fertilizer application in semi-arid areas of Kenya

Njiru, E.N., Ghelle, F.O, , Mutisya, D.L. and Karoki, M
Technical bulletins
GRAIN AMARANTH: AN ANSWER TO FOOD INSECURITY AND MALNUTRITION IN THE ARID AND SEMI-ARID LANDS OF KENYA (ASALS)- Case study of Utithini Women Orphan Child Care Group
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F. Omari, E. Njiru, R. Kisilu, M. Karoki, S. N. Nguluu D. M. Mwangi, M. Kinyanjui