

Realizing the potential of vegetables

Building healthier lives and more resilient livelihoods for smallholder vegetable farmers and consumers in Asia and Africa

*2019 Annual Report
ACIAR - World Vegetable Center Partnership Agreement*



The **Australian Centre for International Agricultural Research (ACIAR)** annually supports the **World Vegetable Center (WorldVeg)** to realize the potential of vegetables for healthier lives and more resilient livelihoods in lower-income countries of Asia and sub-Saharan Africa. Sustainable and safe vegetable production, processing and marketing create new jobs and sources of income for smallholder households and increase availability of nutritious vegetables for consumers, contributing to Sustainable Development Goal (SDG) 1 (No poverty), SDG 2 (Zero hunger) and SDG-3 (Good health and well-being).



WorldVeg implements its research and development agenda through three outcome-oriented flagship programs:

- **Safe and Sustainable Value Chains**
- **Vegetable Diversity and Improvement**
- **Healthy Diets**

and one cross-cutting flagship program:

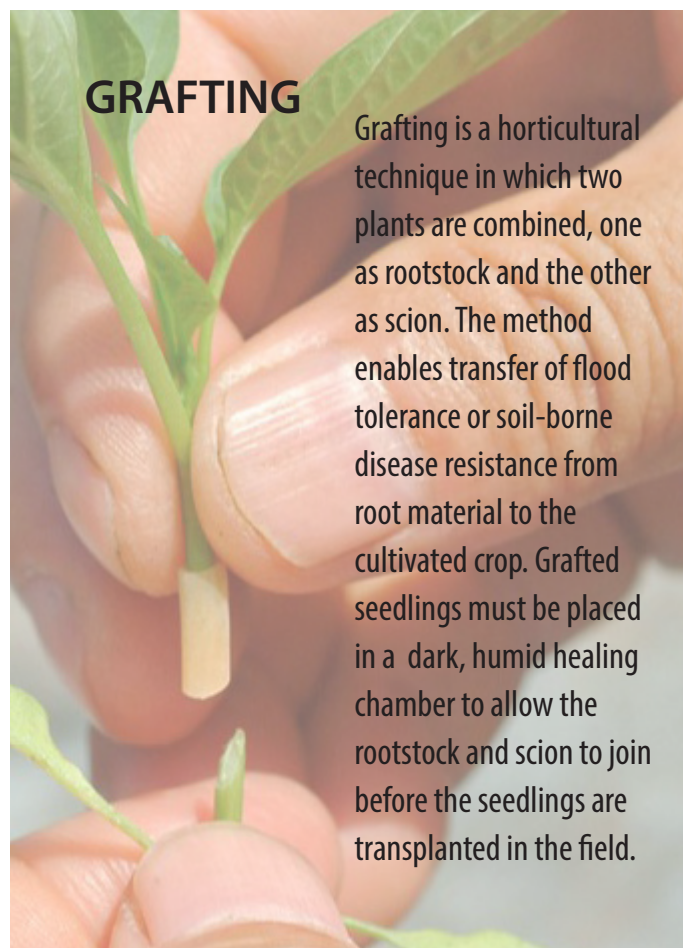
- **Enabling Impact**

Safe and Sustainable Value Chains

The program evaluated and introduced improved agricultural practices to smallholder farmers to produce vegetables that are competitive in the market and safe for consumers. The focus is on affordable, effective, and environment-friendly production methods.

For example, WorldVeg developed a **tomato grafting healing chamber** with PVC pipes and polythene equipped with a small USB-powered fan to create a favorable environment for healing seedling grafts and preventing formation of extra unwanted roots. A solar panel with a power bank can be used in areas where there is no electricity.

Farmers were encouraged to use non-chemical materials to manage pests and diseases in their vegetable fields. In India, an integrated pest management method based on **pheromones** and **biopesticides** was piloted against *Tuta absoluta*, a devastating invasive pest of tomato that originated from South America but has spread globally. Treated plants demonstrated a three-fold reduction in leaf and fruit infestations with yield two times higher than untreated plants.



GRAFTING

Grafting is a horticultural technique in which two plants are combined, one as rootstock and the other as scion. The method enables transfer of flood tolerance or soil-borne disease resistance from root material to the cultivated crop. Grafted seedlings must be placed in a dark, humid healing chamber to allow the rootstock and scion to join before the seedlings are transplanted in the field.

Cotton and okra were tested and used as **trap crops** in commercial eggplant production in Thailand to manage hopper burn damage and whitefly-transmitted yellow mosaic virus disease.

Other non-chemical materials and methods were evaluated for their success in supporting plant growth and increasing profits from vegetable production: **Phytohormones** improved overall growth of tomato seedlings to facilitate faster seedling establishment when transplanting and use of **biochar** as a soil amendment increased yields of African nightshade and amaranth.

A cost-saving method of **planting tomato without staking** reduced production costs by 39% without compromising yield for the first three harvests.



No staking necessary! Field-validated production methods for smallholder farmers reduce costs.

Vegetable Diversity and Improvement

Efforts were made to conserve vegetable crop **biodiversity** for enhanced resilience in the context of climate change, contributing to SDG 13 (Climate action) and SDG 15 (Life on land). WorldVeg analyzed the diversity and conservation status of 126 genebank accessions of African vegetables, providing important information to target future conservation efforts and collection missions in Benin, Cameroon, Ethiopia, Eswatini, Ghana, South Sudan, and Togo.

The flagship program screened and bred more **resilient crops** with higher yield and tolerance/resistance against pests and diseases to address constraints of vegetable production.

African eggplant germplasm was screened for drought tolerance and one highly drought-tolerant line was identified. Two WorldVeg chili pepper lines (AVPP1339 and AVPP1346) were identified as being stress tolerant, high yielding and met consumer preferences in Myanmar. Other vegetable lines with insect and disease resistance were identified for breeding improved crops against thrips, stem fly and Cercospora leaf spot disease in mungbean, whitefly and Crinivirus in tomato, and Pepper yellow leaf curl Thailand virus and anthracnose disease in chili pepper.



Nutritious, fast-growing leafy green vegetables generate good income for farmers and provide essential nutrients for consumers' diets. The WorldVeg Genebank collects and conserves vegetable biodiversity for current and future use.

Healthy Diets

Vegetables are the most affordable source of essential vitamins, minerals and other vital nutrients for the human diet. WorldVeg promotes consumption of safely produced vegetables through home and school garden activities, and encourages households to include enough vegetables and correctly prepare them for healthy diets.

In Nepal, WorldVeg found **linking school gardens and home gardens** demonstrated a significant increase in parents' food and nutritional knowledge and enabled them to harvest more vegetables from their gardens. As a result, the proportion of children's meals that included vegetables substantially increased by 15-26%. The results show that school garden programs must not only try to influence children's food preferences and food behavior, but also that of their parents, while simultaneously making healthy food available in children's homes.

Households in Tanzania learned lemon juice is an **iron bioavailability enhancer**. Adding lemon juice when preparing African traditional amaranth dishes increased the body's ability to absorb the iron content of amaranth by 39%.

WorldVeg promotion of vegetable home gardens in Bangladesh demonstrated that households maintaining **home gardens** for at least 3 years after the promotion were able to produce on average 43 kg of vegetables per year, approximately 49% higher than before. Home gardens had positive effects on women's nutrition knowledge, vegetable production practices, vegetable consumption, empowerment and output market participation, contributing to SDG-5 (Gender equality).



Learning to add a squeeze of lemon juice when preparing amaranth for maximum nutritional benefit and great taste.



Schoolchildren at Ratna Rajva Secondary School in Nepal explain how they planted and tend their garden. Linking school and home gardens increases parents' awareness of nutrition, and prompts them to include vegetables in children's meals.



WorldVeg breeding consortia workshops in Africa (*left*) and Asia. Strong engagement with seed companies and other private sector partners in the vegetable value chain helps ensure the needs of smallholder farmers are addressed in input distribution, production technologies, and commercialization activities.

Enabling Impact

The Enabling Impact flagship finds ways to build an enabling environment to create impact and contribute to SDG 17 (Partnerships for the goals). Collaboration with partners from the public and private sectors strengthens capacity of the partners and smallholder farmers in vegetable production and commercialization. The flagship monitors and evaluates how WorldVeg research and development activities impact vegetable enterprise stakeholders.

WorldVeg established **breeding consortia** with seed company members of the African Seed Trade Association and the Asia & Pacific Seed Association. The breeding consortia are collaborative platforms that (i) enable seed companies with various breeding capacities to access improved vegetable lines for inclusion in their commercial breeding programs more efficiently, and (ii) help align WorldVeg research with consumer and market demand. Data received from members of the APSA-WorldVeg Vegetable Breeding Consortium in 2017 and 2018 showed that breeding material from WorldVeg was incorporated in 45 commercial varieties in 9.5 tons of chili/sweet pepper and tomato seed.

WorldVeg improved capacity of Bangladeshi researchers by training 20 private companies and 2 public entities on the use of **Cytoplasmic Male Sterility (CMS)** for breeding chili pepper hybrids. Use of CMS substantially decreases tedious manual hand pollination and increases efficiency of hybrid seed production. Twenty-six 26 CMS chili pepper lines were developed and distributed to the Bangladesh Agriculture Research Institute; two WorldVeg CMS pairs are now being used to produce the first CMS-based chili hybrids bred in Bangladesh by the public sector.

Through multi-year and multi-location participatory evaluation with Myanmar's national agricultural research system and by training farmers to multiply pure seed, WorldVeg **chili** lines AVPP1339 and AVPP1346 (stress tolerant, high yield, consumer preferred) are now being produced at scale and made available to farmers for planting in the region. In India, two of WorldVeg's best **dual purpose/processing tomato** breeding lines (AVTO1706 and AVTO1707) were shared with the Indian Institute of Horticultural Research to develop processing tomato hybrids in the country.

SUCCESS STORY

Amaranth



A young farmer finds opportunity when a dual-purpose crop turns over a new leaf.



“I surveyed traders at the wholesale market to learn about local demand for vegetables,” said Mohamed Ally Bakari.

With his new bachelor’s degree in hand, young Tanzanian **Mohamed Ally Bakari** searched for a white-collar job, attempted to raise capital to start a business venture—and then decided to take a chance and become a vegetable entrepreneur.

Mohamed planted an improved amaranth variety and followed good agricultural practices. He sold his amaranth at farm gate for 500 Tanzanian shillings per bunch and made a total profit of 510,000 shillings (USD 221) from his 0.5 acres of land.

Mohamed strengthened his public speaking skills by participating in a cooking show hosted by WorldVeg during a nutrition sensitization session. He now has the self-confidence to interact with potential buyers, explain to them the health benefits of vegetables, and convince them to use vegetables in their daily meals.

His marketing approach has a personal touch: by giving neighbors a free bunch of amaranth to taste, he is building demand for fresh produce right at his farm. He already has bought another acre of land to expand his enterprise.



Amaranth (*mchicha* in Swahili) is a popular traditional vegetable with a long cultural tradition in East Africa. The leaves are rich in essential vitamins and minerals (iron, zinc, calcium) often lacking in local diets.

Amaranth grain provides high quality protein; it can be consumed directly or used to fortify starchy staples such as maize flour. The grain is easy to store.

Farm households typically cultivate amaranth in small areas or collect leaves from the wild for consumption or for sale in local markets. Increasing demand for year-round supplies of fresh amaranth in Africa's burgeoning cities is motivating farmers to grow the crop in larger areas under more intensive, commercial-scale production. As more farmers seize the opportunity to improve their livelihoods through amaranth production, they need high-yielding varieties that meet or exceed market requirements.

Despite its many benefits, amaranth has been largely neglected in agricultural research and development. The lack of quality seed of diverse, resilient and high-yielding varieties in a range of leaf colors, shapes, sizes and grain qualities demanded by consumers and market traders has impeded commercial production of the crop.

WorldVeg amaranth lines comprised 59% of the improved varieties, amounting to 1.7 tons of amaranth seed reaching 231,000 farm households in Kenya and Tanzania.

WorldVeg and partners Simlaw Seeds Kenya and the Tanzania Agricultural Research Institute painstakingly tested candidate amaranth varieties in different locations across Tanzania and Kenya, evaluating them for vegetable yield, seed production, earliness, vigor, leaf qualities, size color, tolerance to heat and diseases, and nutrient content.

Participating women and men farmers shared their vast expertise and knowledge, assessing candidate varieties for appearance, cooking qualities, taste and other critical characteristics.

Three outstanding amaranth varieties—AVAM1916, AVAM1938 and AVAM1939—came out on top and were selected to advance along the process toward variety release. Prior to release they will be re-named and seed will be made available to farmers through seed companies or public institutions.

An impact study was conducted during 2019 to quantify the adoption of improved amaranth varieties in Tanzania and Kenya. The study collected data using a questionnaire among vegetable seed producers and elicitation from nine expert panels involving 123 local experts.

The results show that improved amaranth varieties were planted on 51% of the planted areas in Kenya and 70% in Tanzania on a total of 17,502 hectares and reached 404,000 smallholder farmers. WorldVeg amaranth lines comprised 59% of the improved varieties, amounting to 1.7 tons of amaranth seed reaching 231,000 farm households in the two countries.

The impact study demonstrated that investment in research and development by ACIAR and other donors coupled with involvement of the private sector to improve amaranth production through the development and promotion of better varieties and good agronomic practices can and will contribute substantially to better livelihoods and better nutrition in sub-Saharan Africa.

Ochieng, et al. 2019. Adoption of improved amaranth varieties and good agricultural practices in East Africa). Land Use Policy 83:187-194



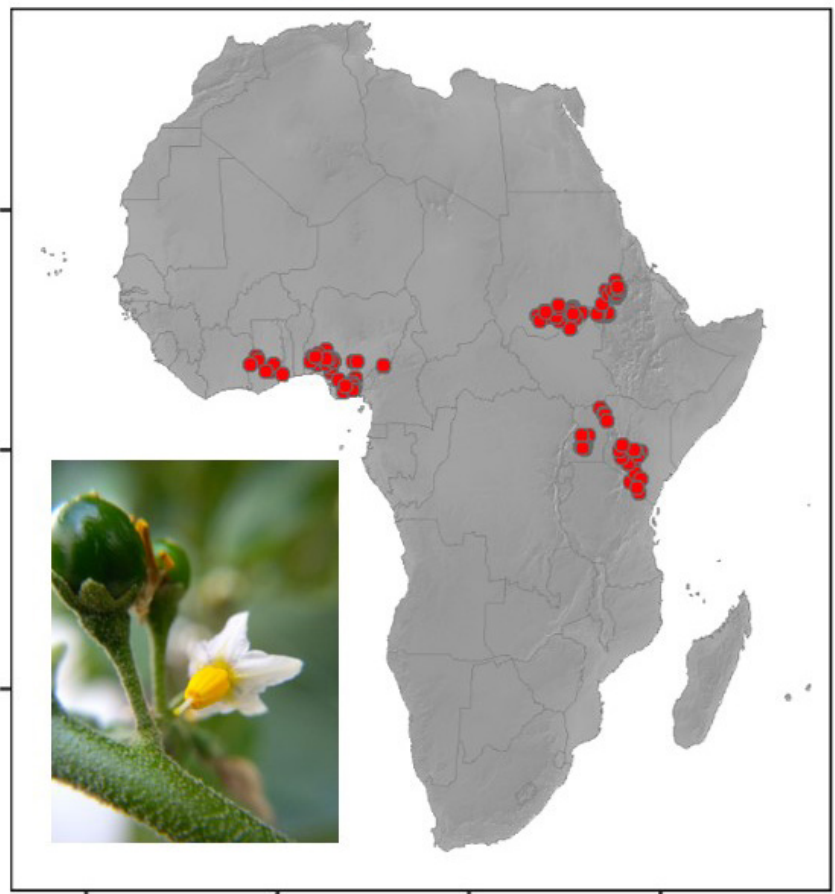
Increasing breeders' seed: Amaranth variety 'Akeri' in production at WorldVeg Eastern and Southern Africa, Arusha, Tanzania.

SUCCESS STORY

Saving traditional treasures

WorldVeg conserves landraces of wild relatives and vegetable crops in Africa.

Partnerships are essential to strengthen networks dedicated to the conservation of vegetable biodiversity in Africa



Sites in Africa where wild eggplant relatives were collected by Kew Royal Botanical Gardens and partners of the Global Wild Relatives Project. Seed of these plants is being multiplied, characterized, and safeguarded by WorldVeg. In the picture: *Solanum anomalum*, a wild relative of eggplant.

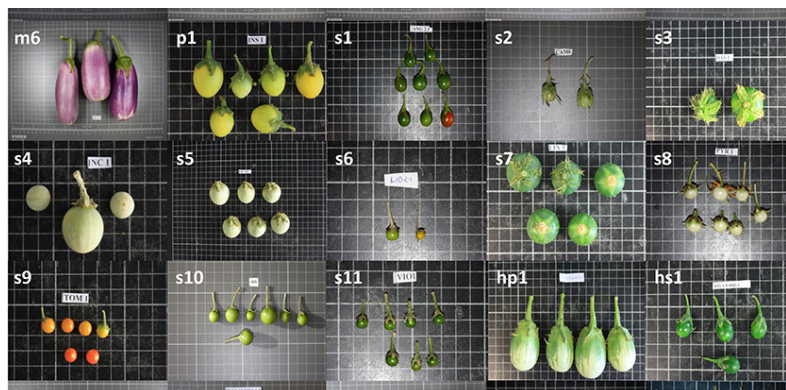
Landraces and **wild relatives** of vegetable crops in Africa have the potential to contribute to the development of nutritious and climate-resilient food production in African countries. However, the survival of these plants is uncertain. Human demand for land and water encroach on natural vegetation, less well-known crops often are neglected in agricultural crop research, and food marketing networks with a preference for common global vegetables standardize what's available to eat. These and other factors are contributing to a global decline in agricultural biodiversity.

With support from international donors such as ACIAR and in collaboration with international and national partners in Africa, the World Vegetable Center aims to rescue these vital genetic resources before they disappear in the coming decades.

To identify hotspots of diversity, WorldVeg collaborates with National Plant Genetic Resources Centers in Eastern and Southern Africa to upload vegetable biodiversity data to public databases with support of the European Union. In total, 126 high-potential African vegetables relevant for people's diets in different regions of Africa have been identified with the World Agroforestry Centre and the Inland Norway University of Applied Sciences.

Among the vegetables with most potential to be mainstreamed into urban markets and consumer diets are leafy amaranth, African eggplant, jute mallow, roselle, spider plant, Ethiopian mustard, okra, and vegetable cowpea. Areas of high vegetable diversity can be found in the coastal regions of West

Africa, in Cameroon, South Sudan, Ethiopia, Tanzania, Madagascar, and Eswatini. These areas coincide with centers of historic cultural diversity or harbor high levels of natural plant species diversity. This vegetable diversity is poorly represented in genebanks and requires urgent conservation action.



WorldVeg works with Kew Royal Botanic Gardens, UK and partners in the Global Crop Wild Relative project to rescue the diversity of eggplant wild relatives from Africa. Through the project, the WorldVeg genebank has received 217 accessions of 18 eggplant wild relatives. The genebank is multiplying seed of these accessions and characterizing the morphology of the plants.

Wild relatives of cucurbits, vegetable cowpea and okra are other priority species to collect in Africa, and new projects are needed to accomplish this. Partnerships are essential and WorldVeg continues to strengthen a network dedicated to conserving the landraces and wild relatives of vegetable crops in Africa.

Looking ahead

ACIAR support for future vegetable research

ACIAR's core funding strengthens the capacity of WorldVeg to conduct research on climate-smart, nutrition-sensitive, farmer-forward practices for regenerative horticulture.

In 2020, ACIAR funds will be dedicated to two research opportunities:

- Investment in a **high throughput phenotyping system** has enabled Worldveg to screen large germplasm sets for traits on interest. In 2020, screening of core collections of tomato, pepper, eggplant, okra, mungbean and amaranth is planned to identify accessions with traits of interest for breeding improved varieties.
- There is a need to **screen okra and chili pepper germplasm collections** in disease hotspots to identify resistance sources for breeding. These crops are heavily affected by Begomovirus diseases and resistant materials for breeding are not widely available.