AVRDC-The World Vegetable Center collaborative activities in vegetable crops research and development in Southern Africa

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Introduction

AVRDC – The World Vegetable Center, Regional Center for Africa (RCA) has been involved in vegetable production, research, training and development in Southern Africa since 1992. AVRDC-RCA works in close collaboration with national agricultural research and extension systems in Africa to:

- Conserve and enhance the genetic resources of selected vegetables.
- Develop improved vegetable varieties, their seed production systems, and sustainable production technologies.
- Disseminate relevant vegetable research information and technologies.
- Train promising African vegetable researchers and extensionists.
- Strengthen the national research institutions.

The current AVRDC-RCA strategic themes for Africa are: Germplasm management and promotion of African indigenous and priority exotic vegetables; sustainable seed supply for AIVs and priority exotic vegetables, and strengthening the capacity of researchers and extensionists of national systems through training, participatory technology development and transfer.

AVRDC in Africa serves as a bridgehead to extend AVRDC’s improved varieties and technologies to Africa, while the NARES, NGOs and the private sector benefit from AVRDC’s R&D activities. In addition, AVRDC in Africa is an effective catalyst for regional cooperation in research, training, and exchange of improved germplasm, technological know-how and information. In Southern Africa, AVRDC-RCA research, training and development activities are being carried out in the following countries; Tanzania, Malawi, Zimbabwe, Zambia, South Africa, Namibia, Lesotho, Botswana, Swaziland, Mozambique, Mauritius, Angola, and the Seychelles. The main activities have involved capacity building programs and implementation of applied vegetable research, development and technology transfer as well as improving seed systems and access to help increase consumption of priority exotic and African indigenous vegetables.

Capacity building and Information dissemination

AVRDC-RCA is hosting a Collaborative Vegetable Research and Development Network in Southern Africa (CONVERDS) that has the following mandates: provide the forum and mechanisms for improving communication and rapid exchange of technology derived from research; through consultation, identify research needs, set their priorities and encourage the NARES of the region to focus on these problems; foster collaborative and complementing research and technical exchanges, always taking into account the institutional strengths, weaknesses and needs of member NARES; minimize duplication of efforts and enable the formation of complementing vegetable
research units that are able to address the production and use problems at the national and regional levels; hold periodic network meetings, as one of the means for developing collaborative plans, evaluating results, and fostering exchange of information; identify NARES partners for collaboration; and to source funding and provide technical support to enable the NARES with lead roles on specific commodities and/or cross-commodity network activities to effectively discharge their responsibilities. Through CONVERDS, new varieties, low cost production technologies, and extensive capacity building programs have been carried out in Southern African countries.

As agricultural productivity and profitability declines, more and more women are working off the farm to generate money for purchasing food, fertilizer, household goods, or medicines. A strong rural economy, which vegetable production promotes, will enhance the livelihoods of women. Women farmers in Africa are the substance that binds African society. AVRDC is committed toward empowering women with education and training, and promoting strong rural economies. Today in Africa, 50% of AVRDC trainees are women. AVRDC-RCA is carrying out (since 1994) long- and short-term regional and special skills training courses in vegetable crops production, research and technology transfer in Southern Africa; and over 1000 research and extension personnel from NARES, NGO's and the private sector have been trained. The trained personnel are helpful in implementation of applied research and technology transfer activities related to vegetable crops. The trained personnel and the diversity of vegetables hosted by AVRDC from its R&D programs are an excellent source of readily available improved germplasm for technology transfer and implementation of applied research and technology transfer activities related to vegetable crops. In addition, the vegetables can be produced under multiple home garden and commercial farming systems that can help diversify the crop production systems as well as help improve consumption to reduce current rates of micronutrient and protein calorie deficiencies, improve food security and diversify diets and income through increased production of indigenous, legume and selected exotic vegetables.

AVRDC is actively involved in vegetable research and development in collaboration with the National Agricultural Research Systems (NARES) in Southern Africa. AVRDC has conducted variety trials with these NARES and carried out participatory National Review and Planning Workshops on vegetable R&D with the Southern Africa Development Community (SADC) countries (1990), Zambia (1996), Tanzania (1998), Mozambique (1999), Mauritius (2001) and currently in Malawi (2003); whereby recommendations and priorities for vegetable research and development were identified.

Information on the production, processing and use of vegetable crops has been disseminated widely. The ongoing programs create awareness at the household level by distributing brochures and leaflets on vegetable production, use and processing technologies.

AVRDC has been cooperating with vegetable farmers based on participatory learning and action research experiences to help identify constraints and feasible solutions to vegetable production in Southern Africa. To introduce new vegetables and related production and marketing technologies in Southern Africa, the socioeconomic units of AVRDC has been conducting ex-ante and ex-post farm surveys, to identify constraints on the expansion of the horticultural sector in general, and evaluating the production and market potential of different indigenous and exotic vegetable crops in quantitative as well as qualitative terms. Several such evaluations have been conducted in Southern Africa. In these evaluations, a comprehensive review and analysis of available vegetable crops and related technologies are conducted for their social acceptability, economic viability, and environmental sustainability as well as the nutritional and economic implications for the poor.
Promotion of improved exotic and indigenous vegetable varieties

Vegetable research and development activities of AVRDC in Southern Africa focus on the main constraints: identification and selection of vegetable diversity suitable for low input requirements, short duration and rich in nutrients; adaptation for farmers use, and organizing access to seeds. To improve the seed systems and on-farm seed production of target vegetable crops; AVRDC has helped increase the supply of seed of low input vegetables and selected high value crops to help reach the most vulnerable households. Additionally, AVRDC is actively engaged in germplasm evaluation of exotic and indigenous vegetables to identify superior lines suitable for adoption in specific localities. This germplasm evaluation has resulted in identification of superior varieties and release of some new varieties that are being promoted and marketed.

In Malawi, R&D activities are being carried out in central and southern regions. The activities include baseline survey studies on indigenous vegetables, evaluation of indigenous and priority exotic vegetables, germplasm improvement, improving access to vegetable seeds, and developing production packages for vegetable crops. Additionally, AVRDC-RCA is actively implementing a program on "Promotion of Neglected Indigenous Vegetable Crops for Improved Nutritional Health." The goal of the project is to improve household food security of resource-poor groups by: safeguarding biodiversity of indigenous vegetables; reducing malnutrition and poverty among small scale farmers and consumers; and diversifying and stabilizing farmers' incomes and nutritional health through better use of indigenous vegetable crops under home garden production and commercial farming systems. This program is being implemented in Central and Southern Malawi in collaboration with the Agricultural Research Department of the Ministry of Agriculture. In Zimbabwe, R&D activities have been carried out on evaluation trials on priority exotic vegetables while in Mozambique, R&D activities carried out have included evaluation trials on priority exotic vegetables, baseline survey studies on the status of the vegetable sector, distribution of vegetable seeds to flood damaged areas in Southern Mozambique and poverty stricken areas in central Mozambique to improve vegetable gardening and reduce malnutrition and poverty. From 2002 and in collaboration with UNICEF, AVRDC has distributed over 2 tonnes of indigenous and exotic vegetable seed to drought-prone areas in Southern Zambia. Evaluation trials on priority exotic and indigenous vegetable crops have also been carried out in Swaziland, Lesotho, the Seychelles, Mauritius, Botswana, Mozambique, Angola, Namibia and South Africa. The programs conducted so far in these countries have been aimed at improving vegetable home gardening and access to seeds to help meet the emergency food requirements and attain food security at the household level.

Vegetable production is an important agricultural activity in Southern Africa. Further expansion of vegetable production offers good opportunities for improving smallholder livelihoods through marketing of high value crops. Yet, vegetable production in this region is limited by short- and long-term constraints that include, but are not limited to declining soil fertility, non-availability of organic inputs, labor shortage, pest infestations, and limited marketing and processing opportunities. AVRDC is trying to address some of these constraints through the intensification of production systems with vegetable legumes to address the causes of land degradation, declining soil fertility, and low and erratic rainfall; use of organic gardening in mixed home garden and commercial farming systems to develop sustainable production systems; promotion of need-based, low-cost technologies; employing IPM approaches to address the high prevalence of weeds, pests and diseases of vegetable crops; improve market access by gauging information on farmer-market linkages and adding value to produce through improved processing.
and storage; and increased awareness to improve the productivity and implementation of enabling agricultural policy.

The use of drumstick tree (*Moringa oleifera*) seed powder is very effective in clarifying dirty water and has been used in some countries in East Africa. *Moringa* is a drought-tolerant tree that can grow throughout SSA and the leaves and immature pods are being consumed widely as a vegetable. Therefore, seed production should be increased by encouraging small-scale farmers to plant or grow this tree on their homesteads or around farm boundaries. AVRDC has been disseminating *Moringa* seeds in Southern Africa for adoption and adaptation.

**Promotion of available technologies and Introduction of improved varieties**

Small-scale farmers in Southern Africa usually keep and maintain small herds of livestock including cattle, goats, sheep, and chickens. Farm manures produced from livestock can be used as organic fertilizers either applied directly or mixed in compost preparations. However, the low availability of livestock manure in peri-urban areas makes it essential to look for alternative low-cost solutions to improve productivity in Vegetable production. AVRDC has been looking at sustainable organic gardening in mixed cropping systems as well as the use of legumes as green manure for crop intensification.

**Indigenous vegetables**

Vegetable varieties used by Southern Africa producers often originate from Europe and other parts of the world and are, therefore, not adapted to local agro-ecological conditions. This is especially true for exotic crops like tomato, hot and sweet pepper, eggplant, cabbage, Chinese cabbage, kale, collards, and lettuce. To minimize or reduce the effect of erratic rainfall pattern and extended dry periods, small-scale vegetable farmers in SSA practice multiple cropping systems. The common cropping system is mixed or intercropping of several crops with variable water requirement. Some of the species in the crop mixture are short and quick maturing with low water needs. These crops consist mainly of leafy and indigenous vegetable species (e.g., amaranth, jute mallow, sweet potato, African eggplant, nightshade) that have better chances of reaching maturity before drought occurs. This array of indigenous vegetable varieties are well adapted to local agroecological conditions and are less susceptible to local pests and diseases, but are usually lower-yielding varieties. There is thus a need to identify improved vegetable varieties that are both adapted to local conditions and high-yielding. AVRDC has developed a wide variety of leafy and indigenous vegetables that are short-maturing, high yielding and nutritious, and are being tested for their adaptability to local agroecological conditions and/or tolerance to major pests and diseases in Southern Africa. Once a variety is identified, it is used as such after genetic enhancement or incorporated into breeding programs to include desirable traits into other varieties. Research for improved varieties is directed toward collection, identification of open-pollinated varieties for resource-poor vegetable producers, genetic enhancement and evaluation for superior traits, seed multiplication, development of production technologies, seed distribution to farmers and NARES, and seed multiplication at farm level.

The implementation of Applied Research and technology transfer as well as improving seed systems will play a catalytic role in increasing consumption of high value vegetable crops as well as low input African Indigenous Vegetables (AIVs), increase accessibility to quality seed and support community-based production and marketing networks for AIV seed and vegetables. AVRDC is focused on improving the production of indigenous
vegetables with the aim of improving nutrition and giving farmers new opportunities to increase their incomes. AVRDC has joined with NARES in Africa and IPGRI to collect and conserve germplasm of more than 1000 indigenous vegetables from Africa, including selections of nightshade (Solanum scabrum S. americanum, S. villosum), African eggplant (Solanum aethiopicum, S. macrocarpon, S. anguivi), Ethiopian mustard (Brassica carinata), spider-flower plant (Gynandropsis gynandra), amaranth (Amaranthus dubius, A. hybridus, A. lividus, A. thumbergii, etc), jute mallow (Corchorus olitorius), okra (Abelmoschus esculentum, A. caillei), pumpkin (Curcubita spp.), moringa (Moringa oleifera), sun hemp (Crotalaria ochroleuca, C. brevidens), vegetable cowpea (Vigna unguiculata), and lablab (Lablab purpureus). Promising lines of these crops are being identified—some lines are already purified, characterized, evaluated (AVRDC 2000, 2001, 2002, 2003, 2004) and their cultivation and use have been developed, documented in English, French, and local languages, and are being disseminated. Nutritional tests are also being conducted to understand the special properties of these lines. Twenty promising lines/varieties of okra, pumpkin, moringa, African eggplant, nightshade, jute mallow, spider plant, Ethiopian mustard, amaranth, vegetable cowpea, and sun hemp are currently available for promotion.

**Tomato evaluation and production**

Despite its relative importance and level of usage, tomato yields in Southern Africa average as low as 6 t/ha, and are among the world’s lowest (FAO 2004). The old tomato varieties -- Marglobe, Money Maker and Roma -- are still, despite their susceptibility to diseases and other undesirable features, the cultivars of choice of many Southern Africa farmers. It is very important to improve or replace these cultivars with disease resistant and higher yielding varieties to improve productivity and consumption and to reduce the hazardous effects of pesticides on the environment and on human and animal health. In 1994 AVRDC initiated a research and development program to address tomato production constraints in Southern Africa. Through these research activities, high yielding and multiple-disease resistant tomatoes (with differential resistance to tobacco mosaic virus (TMV), fusarium wilt, root knot nematodes and tolerance to tomato yellow leaf curl virus (TYLCV) have been developed. These multiple disease resistant lines have shown a fruit yield potential ranging from 60 to 100 t/ha in comparison to 6-16 t/ha average in Southern Africa Region versus a world average of 27 t/ha (FAO, 2004). In 1997 two AVRDC tomato lines were officially released for general cultivation in Tanzania; and in 2002, two more lines were released for general cultivation in Malawi. Through public-private sector partnerships, the two lines of tomato released as varieties in Tanzania have virtually replaced the old tomato varieties among farmers. The two varieties have not only changed the yields and income obtained by farmers but has also changed the seed market balance from that of over dependence of imported seeds to that of an inward-looking attitude among tomato growers (Ministry of Agriculture 2004). These lines and additional others are currently being evaluated in Zambia, Zimbabwe, Botswana, Namibia, South Africa, Swaziland, Lesotho, Rwanda, Kenya and Uganda. Two AVRDC lines have performed well in research trials in Zambia. The two promising lines are expected to be pre-released in Zambia after on-farm trials. AVRDC has also developed lines resistant to late blight caused by *Phytophthora infestans*, one of the most devastating diseases of tomato in the African highlands. These lines are being evaluated in Tanzania and will be pre-released soon. In addition, AVRDC researchers have recently bred tomato lines that are up to 10 times richer in beta-carotene, the precursor of vitamin A in human digestion. Promotion of this “golden tomato” has the potential to create an impact on reduction of malnutrition in Southern Africa. Additionally, research at AVRDC has revealed that cooking significantly increases iron bio-availability in vegetables. Tomatoes, including cherry tomatoes, are not only rich in beta-carotene and iron, its micronutrient bioavailability is also high (with or without cooking). Tomato is one of the few vegetables that can enhance the bioavailability of...
iron in rice and beans when rice or beans and tomato are mixed together. The introduction and promotion of these lines are ongoing and their production systems will help diversify diets and improve the nutrition, health and income of poor vulnerable communities in Southern Africa.

In addition, AVRDC has developed and is actively promoting in Africa new varieties of vegetable soybean, mungbean, sweet and hot pepper, onions, and eggplant; some of the lines have been officially released. The diversity of vegetables hosted by AVRDC from its research and development programs would be an asset to Africa in terms of being a good source of readily available improved germplasm for technology transfer. In addition, the vegetables could be produced under cereal and agroforestry-based home garden and commercial farming systems that can help diversify the crop and livestock production systems as well as help improve consumption to reduce current rates of micronutrient and protein calorie deficiencies, improve food security and diversify diets and income through increased production of indigenous, legume and selected exotic vegetables. A major strategy in Southern Africa is to improve year-round production of different vegetable varieties under low input supply and use of low-cost irrigation systems.

**Pepper evaluation and production**

In sub-Saharan Africa, the biggest constraint to pepper production are diseases that in many cases can create yield losses of up to 50%. The use of genetic resistance remains the best control strategy. Pepper (*Capsicum spp.*) including sweet pepper (*Capsicum annuum*, L. *Var. annuum*) is said to be the world’s second most important solanaceous vegetable after tomatoes. Growers in Southern Africa face serious production constraints due to susceptibility of the crop to many diseases and pests. As a result, the yield is still quite low. The use of genetic resistance remains the best control strategy. Since 1986, AVRDC has given priority to breeding multiple disease resistant sweet pepper lines and selection of the best lines with good horticultural traits for adaptation. Since 1997, an ongoing collaborative project between AVRDC and Institut National de la Recherche Agronomique (INRA) in France has tested multi-disease resistant (Cucumber mosaic virus, Potato Virus Y and Tobacco Etch Virus) sweet pepper lines in Tanzania, where screening for fungal (*Phytophthora blight*) and viral diseases has been ongoing. In addition, hot pepper is increasingly gaining importance in East and Southern Africa as an export crop in addition to its importance in diversification of crops in home garden systems and income generation in many households. However, the existing varieties have been showing very low yields and are increasingly susceptible to diseases and pests. AVRDC has been developing high yielding and stable chili inbred lines with multiple disease and insect pest resistance for the hot and humid tropics. As part of the AVRDC International Sweet and Chili Pepper Nursery (ISPN and ICPN) trials, sweet and hot pepper lines have been evaluated at AVRDC-RCA, Arusha, Tanzania since 1997 to determine their adaptation to the African highlands.

**Onion evaluation and production**

Onion is considered as a very important vegetable, widely grown and is second only to tomatoes in the tropics. Day length and temperature highly affect plant crop growth during the early growth stages and bulbing requires cool conditions with adequate water supply. Yields achieved by most farmers in Africa are below potential. One of the hampering factors to high productivity is poor cultivar performance. Farmers continue to use old varieties which have lost their genetic potential over time. AVRDC has developed onion lines with multiple disease resistance and high yielding potential. These lines are being evaluated in Tanzania to identify germplasm with superior traits for release and further promotion.
Legume evaluation and production
AVRDC has a wide collection of improved vegetable and grain soybeans to introduce to the region. Vegetable soybeans are harvested when green and can yield as much as 12 t/ha. The green beans are rich in protein, cholesterol-free fat, vitamin E, and calcium. The residue after harvesting the pod can be as high as 30 t/ha. The green residue can be fed to cattle or can be incorporated into the soil. The residue contains as much as 170 kg N, 12 kg P, and 100 kg K. Growing vegetable soybeans can improve soil fertility and generate new jobs through value-added processing. AVRDC’s grain soybeans are either tolerant or resistant to soybean rust and adapted to tropical conditions with a yield potential of about 2.5 t/ha in about 90 days. AVRDC also has some promising vegetable soybeans which have been tested in Tanzania for green manure to improve soil fertility. In Zimbabwe and Mauritius, some of the promising vegetable soybeans have been evaluated and are already being taken up by the local population.

AVRDC has also developed mungbean varieties (**Vigna radiata** var. **radiata**) with synchronised maturity that resist major diseases and can yield about 1.5 t/ha after 60–70 days. Mungbeans are a popular legume rich in iron and easily digestible protein; they can alleviate anemia. The leaves can also be fed to the cattle.

Promotion of IPM technologies
Cabbage and tomato are widely grown vegetables in Southern Africa. One of the most common insect pests on cabbage is the diamondback moth (**Plutella xylostella**). DBM has developed resistance to several conventional synthetic pesticides and often destroys dry-season cabbage crops (Herren and Löhr 2001; AVRDC 2002). Tomato fruit borer (**Helicoverpa armigera**), and whitefly, **Bemisia tabaci**, are important pests of tomato; for instance TFB causes fruit losses of up to 24%. Whiteflies transmit tomato yellow leaf curl virus (**TYLCV**), which has emerged as the major threat to tomato production in the tropics and subtropics. In Southern and East Africa, spider mites have emerged as a major threat to vegetable and some cereal crops with heavy infestation observed across many crop commodities. Heavy spraying with miticides has led to the mites developing resistance to common miticides available in the region. Alternative crop protection strategies are needed for DBM, TFB, **TYLCV**, spider mites and diseases and pests of other vegetable crops. AVRDC, in collaboration with ICIPE, has already introduced parasitoids for the management of DBM, namely **Diadegma semiclausum**, **Microplitis plutellae**, **Oomyzus sokolowskii** and **Diadromus collaris** in selected countries in East and Southern Africa. In those specific localities, they have become well established and have drastically reduced the need for pesticide use. Experiments conducted at AVRDC-Regional Center for Africa in Arusha, Tanzania, showed that plants treated with neem seed extract gave significantly lower larval/pupae counts and leaf damage and recorded significantly larger head yields in cabbage (AVRDC 2002). For TFB, sex pheromone traps, nuclear polyhedrosis viruses (**NPV**), and trap crops are available for control. And for **TYLCV**, AVRDC has developed varieties resistant to strains of the disease. These technologies are becoming widely adapted and are ready for dissemination in the region. In collaboration with ICIPE, biological control of these pests as well as screening for pest resistance is being explored in Tanzania to help reduce pesticide use and environmental degradation.

Postharvest shelf life
Vegetables are highly perishable commodities and need special treatment and storage to prevent losses, which are typically between 20 to 60% in sub-Saharan Africa, where there are no special storage facilities. Exposure of vegetables to the sun in most African markets leads to the destruction of vitamin content and other nutrients. Infestation by microorganisms results in deterioration of vegetables during the postharvest period. There is also the loss of produce caused by poor packaging during transport as well as
in the markets. Some of the constraints to vegetable production are the lack of varieties suitable for processing and shipping; inadequate marketing information and skills; poor handling and storage technologies; and undeveloped processing industries. Improved harvesting techniques (optimal time-of-day and stage of plant development), as well as pre-cooling, packaging, and cooling can help to reduce losses during shipping and marketing at the field, wholesale, retail and consumer level. On the other hand, varieties specifically bred for long shelf life can best help reduce the losses attributed to poor storability. AVRDC has bred two tomato varieties, Tanya and Tengeru 97, which have been released in the region. The two varieties have a longer shelf life compared to other existing varieties and now are being grown widely in the region, especially in Tanzania. AVRDC has started research on onion, which focuses on breeding for postharvest shelf life. The Center has been evaluating appropriate varieties/lines for storability under ambient conditions and several promising lines with good storability have been identified.

References


