November 2016
The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

Improving the quality of irrigation water

A Water Research Commission (WRC) study has increased knowledge regarding the nutritional water productivity of traditional vegetable crops.

Background

Amaranth was one of the traditional crops investigated during this study.

Sub-Saharan African countries are facing three interrelated challenges, namely water scarcity, population growth, and food and nutritional insecurity of essential micronutrients (iron and zinc) and vitamin A. Agricultural production needs to increase and has to be achieved against a backdrop of issues such as climate change, soil fertility depletion, and land degradation.

Micronutrient and vitamin A deficiencies affect resource poor households who are located in less favourable areas characterised by poor soil fertility, low yield, as well as a lack of capital and agricultural inputs (specifically water and fertilizer).

Therefore, agriculture needs to re-think agro-biodiversity solutions when planning a food-based approach in curbing micronutrient deficiency.

Traditional vegetable crops are highly nutritious and are drought tolerant when compared to exotic vegetables. However, this assumption has been based on the fact that some traditional vegetables grow naturally in marginal environments that are characterised by poor soil fertility, while depending solely on sporadic rainfall.

In 2012, the WRC funded a project titled 'Nutritional value and water use of African leafy vegetables for improved livelihoods' (**Report No. TT 535/12**). Key findings of this project were that these traditional vegetables have the potential of providing more than 50% of the recommended allowance for iron, zinc and vitamin A.

However, these findings were based on plant samples taken from locations where soil fertility and actual evapotranspiration (ETa), or crop water use, were unknown. As such, further research was needed to better understand the link between management practices, water, soil nutrients, biomass, and nutritional content of traditional vegetable crops.

Beta vulgaris (Swiss chard) was used as a reference crop as it is mostly utilised by resource poor households who eat it as a relish with maize porridge.

Project objectives and methodology

The main aim of the project was to understand the effects of water and soil nutrient interactions on nutrient content of selected traditional crops. The following crops were studied: ***Amaranthus cruentus*** (Amaranth), ***Cleome gynandra*** (Spider flower), and ***Ipomoea batatas*** var. ***Bophelo*** (orange-fleshed sweet potato). Modelling techniques were used to scale out the application of the results.

Three experiments were conducted under a rain-shelter and an open field site during the 2013/14 and 2014/15 seasons at the Agriculture Research Council-Vegetable and Ornamental Plants (ARC-VOP). For the rain-shelter, the experimental design was a randomised complete block design, while the treatment design was a 4 x 3 factorial with two factors/treatments, namely crops and water levels, replicated three times.

Experiments were also undertaken as open field trials with the same three traditional crops.

Results and discussion

Literature findings suggested that traditional vegetable crops are highly nutritious compared to exotic vegetables and that they have the potential to meet the daily recommended nutrient intake of all age groups. However, there was a lack of information on their production practices in the literature.

Results of this study indicate that under no water and severe water stress, Swiss chard produced the highest average raw edible biomass compared to the traditional vegetable crops because the bulky stems of the latter were regarded as not edible and, therefore, were discarded.

The analytical data on micronutrients indicate that traditional vegetable crops are higher in iron, zinc and ß-carotene nutrient content compared to Swiss chard. Under severe water stress conditions, iron and zinc exhibited consistency, whereas ß-carotene decreased significantly.

These results suggest that ß-carotene nutrient content is more sensitive to water stress compared to iron and zinc nutrient content. Moreover, low input agricultural practices (supplemental irrigation and no fertiliser application) did not necessarily affect nutrient content of crops negatively.

In some instances, they actually led to increases in nutrient content. For example, iron content of Amaranth increased from 8.2 to 28.1 mg 100 g^{-1}, whereas, for Spider flower it increased from 7.5 to 34.4 mg 100 g^{-1}. From an agronomic perspective, nutrient content of crops cannot be evaluated in isolation with yield or raw edible biomass, because they are intertwined.

Nutritional yield (NY = raw edible biomass x nutritional content) is a crucial agronomic parameter which indicates the quantity of nutrients which can be harvested during the entire season. Key findings suggest that water stress has a major effect on the nutritional yield of crops.

As the severity of water stress was increased, nutritional yield decreased. The highest average nutritional yield for iron, zinc and ß-carotene was obtained from Spider flower (2 771 g/ha), Swiss chard (276 g/ha) and Amaranth (4 897 g/ha) under no water stress treatment.

These results suggest that more iron and ß-carotene can be harvested from traditional vegetable crops compared to Swiss chard. An opposite result was found for Zinc.

In addition, under low input agricultural practise, the nutritional yield of traditional vegetable crops decreased with ß-carotene nutritional yield showing a major decline.

Increased water stress improved nutritional water productivity of traditional vegetable crops. Ranking the crops from highest to lowest nutritional water productivity for iron and zinc and under the severe water stressed treatment: Spider flower, Amaranth, Swiss chard and sweet potato. For ß-carotene, Amaranth, Spider flower, Swiss chard and sweet potato leaves ranked first to fourth respectively.

Key findings are that:

- Amaranth and Spider flower can be grown under rainfed agriculture and still produce the required micronutrients
- Amaranth and Spider flower are highly productive compared to Swiss chard
- Under low input production conditions (i.e. rainfed and no fertilizer application), nutritional water productivity of the sweet potato storage root will decrease for iron and zinc, whereas it will increase for ß-carotene.

The Aquacrop model was successfully calibrated and validated for selected traditional vegetable crops for canopy cover, profile soil water content, biomass, storage root yield and ETa. This was proven by higher coefficient of determination, lower root mean square error (RMSE), and RMSE-standard deviation ratio.

Summary and conclusions

The findings of this research project indicate that traditional vegetable crops are not miracle crops as suggested by literature, because they require fertilizer and water if they were to be cultivated for commercial purposes. Their added value is that they are tolerant to water stress when compared to Swiss chard.

Moreover, Amaranth and Spider flower are more productive per unit of water used in the production of essential micronutrients and ß-carotene.

It is concluded that traditional vegetable cops are resource efficient in terms of water and fertilizer use when compared to Swiss chard. Moreover, the orange fleshed sweet potato has the potential of being utilised as a leafy vegetable and also as storage root crop.

These crops are suitable for resource poor households who lack access to major inputs for agricultural production. Therefore, resource poor households are encouraged to cultivate hem for household consumption and also for commercial purposes.

The Aquacrop model was successfully calibrated, validated and tested for different agro-ecological zones for the selected traditional vegetables. Interested stakeholders are encouraged to use the model for decision-making and also for identifying suitable locations where selected traditional vegetable crops can grow optimally.

Further reading:

To obtain the report, *Nutritional water productivity of traditional vegetable crops* (**WRC Report No: 2171/1/16)** contact Publications at Tel: (012) 761-9300; Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.