Introduction to the special edition of *Water SA* on indigenous crops, water and human nutrition

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Background

Throughout Africa indigenous and indigenised vegetables and fruit have sustained rural populations for many centuries. Through natural selection by survival under local environmental conditions, aided by collection of seeds from top-performing plants only by local farmers, these have become adapted to these conditions. Unfortunately, indigenous plants have received scant attention by researchers in Africa (including South Africa) in regard to improving agronomic practices and upgrading genetic potential. Likewise, little attention has been given to studies on their nutritional value and the bio-availability of nutrients contained in them. It seems as if there has recently emerged new interest amongst South African researchers in these crops. It is hoped that this publication will help to promote this interest further.

On 19-20 September 2006 an *'International Symposium on the Nutritional Value and Water Use of Indigenous Crops for Improved Livelihoods'* was held in Pretoria, South Africa. This special edition of *Water SA* contains 3 articles prepared specifically for this edition and 13 articles that are peer-reviewed revised versions of papers originally presented at the symposium. The unedited early versions of these 13 papers, as well as 5 other papers that had been presented at the symposium, are available on a CD-ROM which can be obtained from Prof André Oelofse, University of Pretoria, at Andre.Oelofse@up.ac.za

The primary aim of this symposium was to bring together experts in the fields of agriculture and nutrition who focus on the contribution that indigenous and other traditional crops can make to improve human nutrition. Agriculturists are concerned with improving the production of food, both in terms of quantity and quality. Nutritionists are concerned with determining the quality of different foods and promotion of the adoption of high-quality diets by people. Unfortunately experts from the two groups often work in isolation from each other, without adequate effective interaction between the two groups. According to the participants, the bringing of the two disciplines together at the Symposium was a major breakthrough. This message was carried through during the process of compiling this special edition.

Setting the scene

South Africa is a net exporter of food, including various subtropical, citrus and deciduous fruits. More than enough vegetables are also produced. Yet, a large proportion of South Africans are food insecure or under-nourished, as is abundantly clear from the articles in this volume. Even more serious are the widespread deficiencies in essential vitamins and mineral element nutrients, of which vegetables and fruit are the main sources, in the diets of vulnerable groups.

In and around major cities and towns adequate amounts of vegetables and fruit are usually commercially available, but high retail prices put these beyond the means of the poor. In rural areas, especially remote rural areas, these types of vegetables and fruit are often scarce due to inadequate transport infrastructure. As a result, the vegetables and fruit that are imported into these areas tend to be even more expensive than in urban areas. Own production of such crops could improve access, but access to good quality seed or planting material, inputs to ensure plant nutrient availability and plant protection, water and specialised advisory services is usually severely limiting or non-existent (see the first article in this edition by Jansen van Rensburg et al.). In such situations reliance on indigenous and indigenised vegetable (and fruit) crops becomes increasingly more important.

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In the context of Africa, indigenous crops are crops that have originated in Africa (Schippers, 2002, 2006). These include a wide range of species that are consumed as human food. Amongst them are several species that are described as ‘‘green leafy vegetables’’, because their leaves and stems are the main parts of the plants that are consumed. Present varieties have evolved over many centuries of survival under local environmental conditions and thus became adapted to these conditions. In many cases dedicated local farmers have aided the process by keeping only seeds from the best plants for planting during the following season. Probably the best-known and most widely consumed indigenous leafy vegetables consumed in South Africa are *Amaranthus* species (‘‘wild spinach’’), melons and cowpeas.

Indigenised species, within the context of Africa, are species that originated in other continents, especially Asia and South and Central America (Schippers, 2006), but have become part and parcel of traditional African food culture and agriculture. Over long periods, often over many centuries, local (‘‘indigenous’’) varieties of indigenised crops have evolved by means of similar processes as described for indigenous crops. Maize is probably the main indigenised food crop in South Africa. Amongst others, acid- and aluminium-tolerant maize cultivars that produce up to double the yields of acid- and aluminium-sensitive cultivars in strongly acidic soils, evolved in the East Pondoland area of the Eastern Cape Province and KwaZulu-Natal (Mendes et al., 1985). Pumpkins and sweet-potatoes, which originated in Central and South America (Schippers, 2006), are amongst the best-known and most widely used indigenised green leafy vegetables in South Africa.

Many may be surprised that crops like pumpkins, melons and sweet-potatoes are described as green leafy vegetables in various articles in this edition. The leaves, young shoots and growth tips of these crops are indeed very important green leafy vegetables, and in the case of pumpkins and melons even their flowers. Their contribution as green leafy vegetable is probably most important during seasons of scarcity of other green leafy vegetable material, e.g. during spring and early summer in Limpopo Province (Khuvutlu and Laker, 1993). In addition to the production of pumpkin leaves and shoots during the spring scarcity period, irrigation farmers at Middle-Letaba irrigation scheme also produced okra, a summer crop, as green leafy vegetable in winter (Khuvutlu and Laker, 1993). This crop yielded less during winter than in summer, but due to the big scarcity of green leafy vegetables during winter it meant bridging of the ''winter hunger gap''. Serious concern about the low intake of green leafy vegetables during winter is clear from the article by Faber et al. in this edition on micronutrient uptake by 2-to-5-year-old children. It is evident that crop selection for different seasons and planning of crop sequences to ensure adequate year-round provision of green leafy vegetables should be an important strategy to achieve balanced diets, but in most of South Africa this can only be achieved if the crops can be grown under irrigation during the long non-rain winter seasons.

In several articles in this edition concern is expressed about the decline in intake of indigenous and indigenised green leafy vegetables, especially by young people, because they see it as food for the poor and a humiliation to eat it. Leafy vegetables are mostly consumed as a soft green relish together with starchy food from grains. In the northern parts of South Africa it is *inter alia* consumed as green relish together with maize porridge. The article by Diouf et al. in this edition raises a new angle to this in the sense that the consumption of green leafy vegetables may be strongly related to the availability and consumption of the starchy material together with which it is traditionally consumed. Change in the consumption patterns of grain-based staple foods is likely to affect the intake of the green leafy vegetables.

Another concern expressed in various articles in this edition is that reduction in the amounts of green leafy vegetables in the diets of people may have serious negative impacts on their vitamin and mineral element nutrition. This could *inter alia* increase health risks. Green leafy vegetables are generally rich in these nutrients and thus can supplement deficiencies thereof in staple foods. An example is zinc, which after phosphorus is the second most deficient of all essential plant nutrients in virgin soils worldwide (Laker, 2005a). The ability of the staple grains maize, rice and sorghum and beans to absorb zinc is very poor, especially maize (Alloway, 2004; Laker, 2005a). This problem has been aggravated by the development of the ''Green revolution'' high-yielding variety maize cultivars, which have far lower zinc absorption capabilities than local cultivars that evolved on zinc-deficient soils (Alloway, 2004). Thus ''balancing'' this in the diet with intake of sufficient green leafy vegetables becomes even more important, as is selection of green leafy vegetables that are 'super accumulators' of important micro-mineral nutrients. The article by Astereda Mnkeni in this edition provides evidence that this is possible.

Attempts will have to be made to improve the yields and acceptability of green leafy vegetable crops through selection and breeding. In the process every effort should be made to avoid losing critically important genetic characteristics of a crop that may be needed later and effective well-preserved gene banks must be established. During the past 30 years or so there have been cases where highly developed crops in the developed world came under severe threat and only genetic materials from the fields of remote small-scale farmers could save them. For example, about 20 years ago the yellow-dwarf virus started devastating California's barley crop but disaster was avoided by breeding in a barley gene conferring resistance to the virus. This gene was found in Ethiopia, where it was 'the product of centuries of selection, adaptation and nurturing by Ethiopian farmers' (Bryant, 1994).

Even though indigenous and indigenised green leafy vegetables are often described as drought-tolerant crops, availability of water is a key issue in most areas in Africa, including most of South Africa. Due to low rainfall and very high potential evapotranspiration (due to the high temperatures and low relative humidities), more than 80% of South Africa is classified as hyper-arid to semi-arid (Bennie and Hensley, 2001). Even areas receiving somewhat more than 700 mm rain/a are classified as semi-arid – as is the case in the rest of Southern and East Africa. Less than 10% of South Africa is classified as humid. Furthermore, rainfall is strongly seasonal. Most of the country receives summer rains, with very little rain falling in winter. Most of the summer rainfall areas are characterised by annual mid-summer droughts, mainly in January. In the eastern coastal areas the mid-summer drought lasts particularly long. Further north, in countries like Kenya and Tanzania, they even talk of annual small and big rain seasons, with droughts in between these two. The long winter and shorter, but more intense (because of the high temperatures), summer droughts can be mitigated by storing as much as possible rain water in the soil during the rain season for use by crops during the dry season. This can be augmented by efficient ex-field or in-field run-on rain-water harvesting techniques (IFAD, 1992; Hensley at al., 2000). To be effective one requires crops or cultivars with root systems that can effectively exploit water stored in the subsoil. In this regard the differences between different cowpea lines reported by De Ronde and Spreeth in their paper in this edition give an excellent example.

In many areas irrigation is essential, if water is available. Very efficient indigenous irrigation systems have evolved in various parts of Africa (De Lange, 1994; 2003). It should be kept in mind that so-called modern water-saving irrigation systems like drip- or micro-sprinklers are not the best systems everywhere. Sometimes the necessary support systems (spare parts, knowledgeable advisors, etc.) are not available and in addition they are not suitable for various South African soils (Laker, 2006). Under such circumstances and on such soils indigenous short-furrow systems are more effective (De Lange, 1994; Laker, 2006). The article on the commodity systems of two green leafy vegetables by Van Averbeke et al. in this edition also reports on effective small-scale irrigation using a short-furrow system. Much irrigation water can be saved by using water-saving indigenous irrigation systems, like the clay-pot system. Daka (2001) found up to 70% water saving on various vegetable crops by using the clay-pot system instead of conventional irrigation systems.

The articles in this edition, although small in number, address a wide range of the issues raised thus far. For this reason this edition provides an appropriate foundation for further research on leafy vegetables in South Africa and their linkages with water and human nutrition.

Among the aspects that need serious attention in regard to improvement of the contribution and role of green leafy vegetables in the diets of especially less privileged South Africans are:

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- The development of an effective system of collecting seed from top-yielding plants that are adapted to specific environmental constraints and making these available to farmers. The paper by Diouf et al. in this edition highlights the contribution of the effective exchange of seed between farmers from distant places, and even neighbouring countries, at the big markets that are so typical of West Africa.
- The propagation of seed and other plant materials (e.g. sweet-potato vines) of plants that are presently known to be good performers in nurseries and making these available within reach of farmers
- The collection of the widest possible diversity of accessions of as many types of green leafy vegetables as possible and screening these for qualities like micronutrient content, drought tolerance, etc., with a view to propagating seeds and plant materials (cuttings) from the best ones and making these available to farmers
- The commodity chains, being the journey from seed to plate, of the different leafy vegetables consumed in South Africa need to be documented and analysed with a view of identifying aspects that warrant improvements
- The bioavailability of the nutrients contained in the different leafy vegetable species and the effects of the processes of preserving and preparing these vegetables on their nutrient contents need to be determined
- The water-, nutrient- and plant-protection requirements of the different leafy vegetable species consumed in South Africa need to be determined in order to assist their potential development into important fresh produce commodities
- The efficiency and applicability of different water-harvesting techniques for different scenarios needs to be determined with special reference to home gardening.

Structure of this special edition of *Water SA*

The articles in this edition are grouped in a logical order. The 1st group (Articles 2 to 4) consists of 3 articles that were prepared specifically for this edition after the Symposium. The 2nd group (Articles 5 to 17) consists of 13 articles that are based on papers delivered at the Symposium. The first 8 of these articles (Articles 5 to 12) deal with the production and development of African leafy vegetables. The last 5 articles in this edition (Articles 13 to 17) deal with African leafy vegetables in human nutrition.

Key contributions of individual articles

Article 2 by Jansen van Rensburg et al. sets the scene for the rest of the publication. It presents an overview of the use and status of green leafy vegetables in South Africa, both indigenous and indigenised and provides a comprehensive outline of the characteristics, properties and uses of 7 important groups of green leafy vegetables.

Article 3 by Wenhold et al. discusses human nutrition in relation to small-holder agriculture, the role of agricultural interventions and the role of water in human nutrition. An interesting aspect is the use of nutritional water productivity, expressed as the quantity of water used per unit energy and per unit protein produced, as indicator of water use efficiency for a variety of foods. Usually water use efficiency is expressed as the quantity of water used per unit mass food (e.g. kg grain) produced. A shortcoming in the table giving the nutritional water use productivities is that it does not include any values for green leafy vegetables.

In Article 4 Van Averbeke discusses the contribution of urban farming to food security among the urban poor in South Africa using a case study to illustrate the nature of urban agriculture and its constraints. Rapid urban migration of poor people from rural areas has increased the need for in-depth investigation of this type of agriculture in poor urban settlements throughout the country. This article is of such importance that it should be brought to the attention of town planners and decision makers.

The group comprising the symposium papers (Articles 5 to 17) commences with a fascinating article (Article 5) by Diouf et al. on the commodity systems of 4 types of indigenous green leafy vegetables in Senegal. The article gives comprehensive outlines of the production and use of these vegetables. A key aspect emerging from the article is the close correlation between the consumption of specific green leafy vegetables and specific other dishes. Thus it was found that since cowpeas as green leafy material is used together with *cous-cous,* consumption of cowpea green leaf material is strongly associated with the availability of millet. Similarly roselle (*Hibiscus* sp.) is consumed together with a dish consisting of rice and fish. In this case availability of fish seems to be the limiting factor determining the consumption of roselle.

In Article 6 Van Averbeke et al. discuss the commodity systems of 2 green leafy vegetables in South Africa, viz. *Brassica rapa* L. subsp. *chinensis* and *Solanum retroflexum* Dun., including aspects such as production, use and marketing. Farmers have amongst themselves developed effective systems but the wide range of fertiliser application rates used was matter for concern. It could perhaps lead to low yields due to inadequate nutrient supply on the one hand and wasting money on unnecessarily high inputs on the other hand.

In the complementary Article 7 by Van Averbeke et al., the responses of the two crops mentioned above to different application levels of N, P and K were studied. For both N and K yields increased with increased application rates up to a certain point, above which yields decreased. For *Solanum retroflexum* a similar pattern was obtained for P. These results show that low application rates will give low yields, but also that excessive application rates will not only be a waste of money, but could also decrease yields. The response of *Brassica rapa* L. subsp. *chinensis* to P was not only interesting, but could be of great practical significance. On the one hand it produced top yields at quite low application rates on this very infertile acid soil with an extremely low P content. Since P fertilisers are very expensive, this is a very significant finding. On the other hand yields then maintained a plateau at all further increased P application rates, up to excessive levels. This means that this could be a potential crop for those commercial croplands on which P has accumulated to levels where it suppresses yields, which are found in South Africa (Laker, 2005b) or sites of old kraals, which are characterised by excessive P levels. It could possibly be used to 'mine' down P in such cases to levels where other crops could be introduced.

Mhlontlo et al. (Article 8) studied various application levels of sheep kraal manure in comparison with commercial NPK fertiliser as source of fertilisation for an amaranth accession. Even relatively low sheep kraal manure applications gave good results, especially for leaf production and especially during young grow stages when it is best to harvest *Amaranthus.*

In Article 9 Modi reports on the influence of temperature and plant age on yield and composition of 5 amaranth species showing significant differences in protein and amino acid content among species and recorded higher yield and seed germination capacity when the plants were grown under warm conditions, rather than under either cool or hot conditions. For optimum nutritional benefit he found that it was better to harvest amaranth at a young age, which is in any case what the local population prefer to do.

Article 10 by Mnkeni et al. on the nutritional quality of vegetable and seed from different accessions of *Amaranthus* emphasises the huge differences found among different accessions and the importance of screening different accessions for different qualities before recommending them or using them in further selection/breeding programmes, some of which could have significant human health impacts. The leaves of two accessions had much higher ascorbic acid (Vitamin C) contents than those of the other three. The leaves of one of the accessions had a much lower manganese content than the others, which could have negative health implications. The seeds of one of the accessions had much higher calcium, manganese and zinc concentrations than the others – in the case of manganese up to about three times higher. These are all positively related to human health, but being concentrated in the seed instead of in the leaves this presents a problem.

De Ronde and Spreeth (Article 11) evaluated different cowpea lines and mutants for drought tolerance, reporting enormous differences among them. One line which is considered to be a ‘model’ of drought tolerance produced higher yields under water stressed conditions than under well-watered conditions but the unfortunate reality was that this line gave extremely low yields under both conditions and would therefore not be suitable for dissemination among dry-land farmers. One line that gave very good yields under all conditions of water availability had the potential for use as a ‘parent’ for further development, which the researchers did. At the other extreme was one mutant developed from the same parent that was extremely sensitive to water stress. Under well-watered conditions it was among the top three in terms of yield, but under water-stressed conditions it was bottom of the list. Under water-stressed conditions its yield was only 15% of what it was under well-watered conditions. Differences in regard to tolerance to water stress in cowpeas seems to be related to differences between root systems. The ‘model’ drought-tolerant line and a very sensitive line had equal total root lengths, but the water stress-tolerant line developed many more roots in the subsoil and could thus be expected to exploit the subsoil water reserve much better than the shallow-rooted water stress-sensitive line. Two relatively water stress-tolerant mutants also had more roots in the subsoil. However, they had considerably bigger root systems than the poorly yielding ‘model’ line. This could at least partially explain their higher yields. In various other articles in this edition the general statement is made that one of the advantages of cowpea is that it is a very drought-tolerant crop. The differences between different cowpea lines highlighted in this study warn that one should refrain from accepting such blanket statement without verifying it – for any crop.

In the final article dealing with the production and development of green leafy vegetables (Article 12) Gazendam and Oelofse outline isolation of cowpea genes conferring drought tolerance for the construction of a cDNA drought expression library, with the use of a drought tolerant cowpea line and extremely drought sensitive one. It is interesting that the drought tolerant line which was used here was the one that in the previous article was found to be highly drought tolerant, but gave extremely low yields.

In the scene-setting article on the role of African green leafy vegetables in human nutrition (Article 13) Faber and Wenhold give a comprehensive review of various aspects of human nutrition in South Africa. They *inter alia* define malnutrition, give special attention to malnutrition in children, look at addressing the causes of malnutrition and discuss micronutrient deficiencies (specifically Vitamin A and iron).

Maunder and Meaker (Article 14) also give a review of human nutrition in South Africa, but from a different perspective. Attention is given to the *South African Nutrition Guidelines* and how indigenous crops can fit into achieving these. Interventions to improve diets by including indigenous crops are discussed. Concern is expressed about the decrease in the knowledge of indigenous crops among young people and the low esteem in which these crops are held.

Article 15 by Faber et al. enlightens the contribution of dark-green leafy vegetables to the micronutrient (vitamins and minerals) nutrition of 2-to-5-year-old children in two rural areas of KwaZulu-Natal. The results show that dark-green leafy vegetables can make substantial contributions to the intake of micronutrients but that this is highly variable. It was found that appropriate interventions can increase their contribution significantly. Very significant is the finding that a high proportion of children consumed dark-green leafy vegetables during the last and first quarters, the summer rainfall season in this area. During the first quarter, i.e. the last part of the rain season, the proportion of children consuming dark-green leafy vegetables was as high as 86%. During winter (the dry season) the proportion of children consuming dark-green leafy vegetables dropped to very low levels. During early winter it was as low as 36%. During early spring consumption of spinach alleviated the low consumption of dark-green leafy vegetables.

Van Averbeke and Khosa (Article 16) found that dry-land farming significantly contributed to household food security, especially among the ultra-poor. Small-scale irrigated vegetable production, using the drum-and-drip system, substantially raised the amounts of Vitamins A and C available to households, but could not make a meaningful contribution to alleviate the deficiency of protein in the diet of ultra-poor households or the iron deficiency in the diets of all categories of households. Income, however, not farming, was the most important determinant of the food security of rural households.

In the final article (Article 17) Choge et al. review the possible contribution of *Prosopis* pods as a human food. Strictly speaking this article does not address the core theme of the symposium, because *Prosopis* is neither indigenous to Africa, nor a green leafy vegetable. It has, in fact, became an alien invader that has to be eradicated in Kenya. The approach was to look at the possibility of using the pods as human food while removing them to reduce further spread of the plant, instead of just simply destroying them. The lesson is to not just wastefully destroy something that is unwanted, but rather to destroy in a positive way that could help to alleviate household food insecurity in poor communities.

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