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Watermelon production in Africa: challenges and opportunities

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ABSTRACT

There is a growing realization in African countries for the need to enhance the production of xerophytic crops, including Watermelon, *Citrullus lanatus* L., in the face of climate change. The objective of this review is to explore challenges and opportunities in watermelon production in Africa. Watermelon is adaptable to most of tropical, and subtropical, Africa, due to its low water requirement and has the potential to be a commercial crop. However, minimal research has been applied to its breeding and production in the continent. Lack of improved varieties, poor production systems, perishable nature of the fruit, and lack of harvest and post-harvest preservation technology hamper large-scale production. Research, particularly in watermelon production practices and breeding, is needed if its true potential in Africa is to be realized.

KEYWORDS
Citrullus lanatus; cucurbit; lycopene; xerophyte

Watermelon (*Citrullus* spp.) is a xerophytic tropical fruit, belonging to a Cucurbitaceae family.

Other crops of importance in this family include cucumber (*Cucumis sativus* L.), melons (*C. melo* L.) and squash (*Cucurbita moschata* Duch.). The crop is a warm, long-season, trailing, prostate, annual which has monoecious and/or andro-monoecious sexuality (Boualem et al., 2016). Watermelon fruit has a thick rind (exocarp) that has variable pigmentation with a solid or striped appearance, a fleshy mesocarp, and an endocarp which varies in color from white to yellow or red (Bahari et al., 2012; Munisse et al., 2013). Three types of watermelon are grown in drier regions of Africa: the dessert type (*C. lanatus* var. *lanatus* L), the cooking type [*C. lanatus* (Thunb.) Matsum. & Nakai var citroides] and the seed type (*C. colocynthis* L. Schrad.). Dessert watermelon is grown worldwide, has a characteristic sweet taste, a low-calorie fruit used mostly in salads and juices (Bahari et al., 2012; Gbotto et al., 2016; Leskovar et al., 2004). The cooking type, also called cow watermelon, is normally used as animal feed, for cooking thick porridge, or mixed in dry maize (*Zea mays* L.) grain

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(Mujaju et al., 2011a). The seed type watermelon is mostly grown in Central to West Africa and is used to extract oil, make egusi soup, snacks, and flour (Jensen, 2012).

Watermelon flesh is a source of carotenoids, Vitamins A, B6, C, lycopene, and antioxidants. Watermelon rinds are edible containing many nutrients (Jensen et al., 2011). Pickled watermelon rind is consumed in the Southern US. In China, rinds are stir-fried, stewed, or pickled. Watermelon juice can be made into wine, or other traditional brews. In Sudan and Egypt, watermelon seeds are roasted, salted, and eaten as snacks. Watermelon fruit is used as a source of drinking water during drought seasons in parts of Sudan and Nigeria (Ayodele and Shittu, 2013; Goda, 2007).

Statistics on watermelon production (dessert type)

Presently, Asia accounts for more than 80% of worldwide watermelon production. China is the number one producer accounting for 67.6% worldwide. Africa, Europe, and North America have similar production output, around 3–4 million tonnes annually. In Africa, in 2017, watermelon accounted for 5.4% of the harvested area devoted to vegetable production, contributing 5% to world watermelon production. Algeria is the leading watermelon producer in the continent (1.87 million units per year), sixth in the world, contributing 1.6% to worldwide production, followed by Egypt (1.7 million units yearly), eighth in the world. Currently, Africa, as a whole, is the third producer of watermelon in the world (Anonymous, 2019). In Africa, watermelon production systems differ depending on agro-climate, from greenhouses to open field with varying levels of technological application. In most rural communities, watermelon is grown as an intercrop with minimal inputs.

Nutritional value and health benefits of watermelon

Lycopene, Vitamins A, B6, C, carotenoids, and antioxidants are some nutrients found in watermelon (Maoto et al., 2019). Watermelon is a diuretic and contains large amounts of β-carotene, a precursor of Vitamin A (Leskovar et al., 2004; Naz et al., 2014). Lycopene, a phytochemical, is an important intermediate in the biosynthesis of many carotenoids, including β-carotene, responsible for yellow, orange, or red pigmentation. Like all carotenoids, lycopene is a polyunsaturated hydrocarbon and insoluble in water. Lycopene's deep red color is responsible for its antioxidant activity and has been extensively studied. Watermelon consumption has increased, owing to its nutritional profile and allied health benefits. The fruit is effective in reducing cancer, cardiovascular disorders, diabetes, blood pressure, and obesity (Edwards et al., 2003; Lum et al., 2019; Naz et al., 2014). Quantitative assessment indicates that watermelon has 46% calories, 20% vitamin C, and 17% vitamin A and has higher lycopene than tomato (Biswas et al., 2017;

Leskovar et al., 2004). Lycopene is useful in food coloring (registered as E160d) and approved for use in the USA, Australia, and the EU due to its strong color and its non-toxicity (Naz et al., 2014). Watermelon is inexpensive and nutritious and readily available to all socio-economic groups in Africa throughout the summer. It is a traditional food in Africa with the potential to improve nutrition, boost food security, foster rural development, and support sustainable land conservation (Ufoegbune et al., 2014). There exists the opportunity to popularize watermelon and provide benefits to African communities from widespread consumption of the crop.

Challenges on watermelon production

Fruit quality and yield determinants

Fruit quality is an important attribute in the production of watermelons for a specific market (Kuvare, 2005). Generally, the market prefers red as opposed to yellow-fleshed fruit primarily due to lack of yellow-fleshed cultivars with high-quality fruit and consumer resistance. Other cultivars are prone to physiological problems such as cracking, hollow-heart, mealy textures, or a lack of uniformity in fruit shape (Kpenavoun et al., 2019).

The most important watermelon pests are leaf-chewing beetles and sucking insects, which damage leaves, flowers, and root-knot nematodes that affect water and nutrient uptake (Abderrahmane and Lahcen, 2015; Alao et al., 2016). Diseases of economic importance include mildew, fusarium wilt, mosaic viruses, and bacterial rind necrosis (Anonymous, 2011; Said and Fatiha, 2018). It is important to note that watermelon is produced with minimal fertilizer and pesticide inputs in Africa and is usually grown as an intercrop; thus, it is not considered a priority when allocating land for agricultural production. This implies that some pests, though not of great concern in other production systems, are of significance in Africa.

Traditional production methods

Little research on watermelon production has been done in Africa compared to cereals and legumes (Davis et al., 2008). Farmers use a range of production methods which demonstrate the diversity under which the crop is grown, and different niches the crop occupies in farmer livelihood. Most watermelons are grown for consumption by smallholder farmers in semi-arid regions of Africa, mostly under rainfed conditions, and to a lesser extent with supplemental furrow irrigation. However, yields are low mainly due to erratic rainfall. In Mali, Northern Africa, along the Nile river, where it is possible to irrigate, watermelons are grown as cash crops. Seed is mostly sourced through an informal seed system which further compromises yield. Furthermore, most farmers rely on landraces with few having access to improved, well-characterized cultivars.

Watermelon cultivation has not had a high level of technological improvement such as use of new hybrids, fertilizer, and processing in Africa compared to other crops (Kahan, 2013). Watermelon cultivation and processing are labor-intensive with mature fruit collected by hand. The challenge of the inaccessibility of modern inputs to farmers implies they resort to traditional production methods which limit output. In Africa, most farmers rely on their own self-saved seed, stored without special treatment, which compromises crop stand and ultimately yield (Munisse et al., 2013). Watermelon production in Africa lacks capital investment, technology for large-scale production, and given the perishable nature of the crop production will likely remain constrained despite its high potential as a commercial crop.

Level of management practices, whether organic or conventional, affects watermelon quality. High input management practices in watermelon produce greater marketable yield, higher number of marketable fruit/plant and higher fruit weight than low input management practices (Kahan, 2013). Good management improves yield, lycopene, and vitamin C levels (Davis et al., 2008; Leskovar et al., 2004).

Research on watermelon

Despite the importance of watermelon insufficient research has been done under intensive production systems within Africa (Kuvare, 2005). Research on genetic diversity was done in Namibia, Nigeria, and Zimbabwe establishing a baseline for future breeding, possible use, and analysis of heterotic patterns. Only a few studies describe a small fraction of breeding. In Ghana, watermelon accessions were evaluated and compared based on 11 quantitative morphological traits and there was variation among accessions, mainly based on fruit size and weight (Gbotto et al., 2016). Consequently, fruit morphological traits were used for accession identification. Given the diversity of watermelon that exists in the continent more can be done, especially on the development of new, high yielding, cultivars, and genes from Africa's wild types may benefit watermelon research worldwide (Boualem et al., 2016).

Research on genotypic and phenotypic traits of watermelon landraces in different environments is limited in Africa (Said and Fatiha, 2018). Information on cultivar performance under various technologies, environments, and production systems and knowing how these systems affect the quality and phytonutrient content is necessary to ensure high fruit quality, yield, and disease resistance for future breeding (Ayodele and Shittu, 2013). This input is necessary as they affect decisions in breeding. American and Asian watermelon species dominate tropical fruit production worldwide, including within Africa, examples include 'Sugar Baby,' 'Florida Sweet,' 'Carolina Cross' and 'Crimson Sweet'

(Mrema and Maerere, 2018). Africa's watermelon genotypes have not, by and large, been brought up to their potential in terms of quality, production, and availability.

There is a need to diversify watermelon genotypes for wider production and post-harvest management. This will increase demand for watermelons currently not considered as cash crops. Improved post-harvest management will ensure year-round availability of watermelons instead of the glut and scarcity periods that characterize availability in most African countries.

Selection and need for gene banks

The result of many years of domestication, and selection, for desirable fruit quality in production in rural Africa has led to modern dessert watermelon cultivars sharing a narrow genetic base (Gusmini and Wehner, 2005). This presents challenges for breeders whose objective is to improve the crop for disease resistance and other important attributes. Most watermelon breeders, and producers, want to achieve high yield, high fruit quality, and early maturity and endeavor to gather as much diverse germplasm as possible for evaluation (Gichimu et al., 2010; Mrema and Maerere, 2018). Ten accessions from the National Plant Genetic Resources Center of Zimbabwe were morphologically characterized (Mujaju and Fatih, 2011b). Seed banks in Côte d'Ivoire keep seven accessions of watermelons which include *C. mucosospermus* Fursa, *C. amarus* Schrad. *C. naudinianus* Sond, *C. rehmii* De Winter, *C. ecirrhosus* Cogn. *C. colocynthis* (L.) and *C. lanatus* (Gbotto et al., 2016). In Ghana 171 oleaginous watermelon accessions, either collected from different countries or obtained from local farmers are stored in gene banks. The National Gene Bank of Kenya has organized, and implemented, collecting missions for local watermelon landraces and their wild/weedy relatives, covering a wide range of ecological zones and climatic conditions (Eifediyi et al., 2017).

Lack of gene-banks to collect and preserve watermelon germplasm, particularly in some African countries, is a challenge, and drawback, to watermelon breeding (Biswas et al., 2017). Assembling, and conservation, of genetically and morphologically diverse germplasm is essential to ensure the current and future success of watermelon breeding. This is particularly true in that gene banks are the principal source of plant material used for the identification of resources and crop improvement.

Opportunities of watermelon production in Africa

Conditions for watermelon production

Watermelons have evolved several gene expression patterns, biochemical pathways, and physiological mechanisms not present in most crops that allow them to adapt to drought and high light stress (Nanasato et al., 2010). Africa has ideal temperatures, long warm growing seasons, and soils for commercial watermelon production. Watermelons grow best on sandy loam soils, with good drainage and which are slightly acid pH (Anonymous, 2011). As countries in Africa are often affected by drought, adapted watermelon cultivars will be ideal given they require minimum moisture and have high returns on the market compared to other drought hardy crops. Watermelon growth is more rapid during the dry season (under irrigation) than during the wet season (rainfall period) due to erratic precipitation patterns (Mtumtum, 2012). Excess water during maturity can cause fruits to crack which reduces yield and fruit quality (Davis et al., 2008). In Africa, watermelon cultivation is prevalent in drought-prone, semi-arid, areas with an annual rainfall below 650 mm. Most watermelon landraces provide important traits for drought and heat tolerance, such as higher biomass, which would greatly improve crop adaptation to climate change worldwide (Said and Fatiha, 2018).

Natural genetic diversity

The fact that Africa is the primary center of origin of watermelons gives it an advantage when it comes to implementing breeding and pre-breeding research. In most Southern African countries, a large amounts of genetic diversity are found in the wild that can be exploited by breeders to fulfill objectives (Mujaju and Fatih, 2011b). This is coupled with landraces that have been cultivated over long periods of time that are now adapted to the many localities creating opportunities for genetic enhancement. Ancestral genes of watermelons are found in the wild in over thousands of hectares in Botswana and Namibia are likely to provide genetic means for creating new varieties.

Technology and yield stability

A challenge in agriculture is to substantially increase production to meet the demand of rapidly growing populations, especially in developing countries (Kuvare, 2005). High watermelon yield can be achieved by improving cultural practices and developing improved cultivars (Achu et al., 2005). Precision-farming, rational use of fertilization, weed and disease control, and proper training of farmers will allow a change in watermelon production (Gusmini and Wehner, 2005). Hybrid technology use with watermelon varieties has the potential to increase yield while motivating more breeding companies to venture into research on the crop. Important attributes to consider during breeding of watermelon include a hard rind for better handling and storage and higher shelf-life. There is a need to breed for wider adaptation so that the crop can be grown in different climates, and have biotic and abiotic resistance (Ufoegbune et al., 2014).

Summary

There is a need for more watermelon-related research in Africa to present it as a viable cash crop. Considering watermelon originated in Africa, there exists a wide range of germplasm in the wild that can be used to support various continent specific breeding objectives. Deliberate efforts on germplasm prospecting need to be enhanced for sustainability of breeding. More awareness is needed to market fruit for its rich health and nutrition benefits. Suitable agronomic practices for the crop need to be investigated to provide the most ideal environment for crop growth.

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