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RESEARCH ARTICLE

Variability in total antioxidant capacity, antioxidant leaf pigments and foliage yield of vegetable amaranth

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Abstract

Twenty vegetable amaranth genotypes were evaluated for total antioxidant capacity, antioxidant leaf pigments, vitamins, and selection of suitable genotypes for extraction of juice in a randomized complete block design (RCBD) with three replications. Vegetable amaranth was rich in chlorophyll, β-cyanins, β-xanthins, betalains, carotene, ascorbic acid and total antioxidant. The genotypes VA14, VA16, VA18, VA15, and VA20 could be selected as amaranth vegtable varieties with high yields and abundance antioxidant leaf pigments and vitamins to produce juice. The genotypes VA13 and VA19 had above-average foliage yield and high antioxidant profiles while the genotypes VA2, VA3, VA9, VA11, VA12, and VA17 had a high antioxidant profiles and below-average foliage yield. These genotypes could be used as a donor parent for integration of potential high antioxidant profiles genes into other genotypes. The correlation study revealed a strong positive association among all the antioxidant leaf pigments, total antioxidant capacity and foliage yield. Selection based on total antioxidant capacity, antioxidant leaf pigments could economically viable to improve the yield potential of vegetable amaranth genotypes. Total carotene and ascorbic acid exhibited insignificant genotypic correlation with all the traits except total antioxidant capacity. This indicates that selection for antioxidant vitamins might be possible without compromising yield loss.

Keywords: ascorbic acid, betalain, carotene, chlorophyll, β-cyanins, β-xanthins, total antioxidant capacity, foliage yield, correlation

1. Introduction

Recently, antioxidants have attracted considerable interest in food technology researches. Antioxidants, their availability in diets and probable roles in countering deadly diseases such as cancer, neurodegenerative and cardiovascular diseases have been highlighted in various studies (Manach *et al*. 2004; Scalbert *et al*. 2005; Thaipong *et al*. 2006; Surangi *et al*. 2012). Natural antioxidants, particularly in

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fruits and vegetables, have gained the attention of both researchers and consumers. Leaf pigments, such as β-cyanins, β-xanthins, chlorophyll, carotenoids and vitamins, are the major groups of natural antioxidants that are available in vegetables amaranth and involved in defences against several diseases including cancer, cardiovascular diseases, atherosclerosis, arthritis, cataracts, emphysema, retinopathy, neuro degenerative diseases and inflammation, and preventing aging (Cai *et al*. 2003; Alvarezjubete *et al*. 2010; Ritva *et al*. 2010; Steffensen *et al*. 2011; Esatbeyoglu *et al*. 2015).

The interest of consumers in the aesthetic, nutritional and safety aspects of food has increased the demand for natural pigments such as chlorophyll, betalains, and carotene. Betalains are water-soluble compounds found in a limited number of families of the plant order Caryophyllales, like *Amaranthus* having a unique source of betalains and important free radical-scavenging activity (Cai *et al*. 2003; Dantas *et al*. 2015). β-Cyanins are colored betalains from red to purple (condensation of betalamic acid and cyclo-dopa, considering hydroxycinnamic acid derivatives or sugars as residue) and β-xanthins are yellow betalains (imine condensation products between betalamic acid and amines or amino acid residues) (Herbach *et al*. 2006). Similarly, carotene grouped into α-carotene, β-carotene and xanthophyll.

Pigments and their pharmacological activities include anticancer (Szaefer *et al*. 2014), antilipidemic (Wroblewska *et al*. 2011) and antimicrobial (Canadanovic *et al*. 2011) activities, indicating that betalains and carotene may be a potential source for the production of functional foods. Presently, the only commercial source of betalains and carotene is the red beet root. The colorant preparations from red beet root labelled as E-162 are exempted from batch certification. E-162 is used in processed foods such as dairy products and frozen desserts (Stintzing and Carle 2007).

Among the naturally occurring vegetable pigments, betalains are rare and limited to a few edible vegetables, such as red beet and amaranth, while chlorophylls are widely distributed in plant species (Schwartz and Von-Elbe 1980). The active ingredients of betalains and carotene provide anti-inflammatory property to our food and act as potential antioxidants, which can reduce the risk of cardiovascular disease and lung and skin cancers and is widely used as additive for food, drugs, and cosmetic products because of natural properties and absence of toxicity (Kanner *et al*. 2001; Butera *et al*. 2002).

In Asia and Africa, vegetable amaranth is intaken by boiling and making curries, while in Amricas and a few Asian and European countries, it is freshly intaken by making salad or juice. Recently, we extracted red color juice from *Amaranthus* for natural drink containing pigments chlorophyll, betalains, and carotene. It demands more genotypes enriched with leaf pigments. We found lots of variations in vegetable amaranth germplasm in respect to minerals, vitamins, leaf color, quality, and agronomic traits in our earlier studies (Sarker *et al*. 2014, 2015a, b, 2016). Therefore, we studied 20 cultivated genotypes of vegetable amaranth to: i) estimate total antioxidant capacity, amount of antioxidant leaf pigments and foliage yield; ii) select high-yielding genotypes containing high antioxidant leaf pigments for making colorful juice commercially; and (iii) find out possible ways for improving the antioxidant leaf pigments without compromising foliage yield.

2. Materials and methods

2.1. Experimental site

The experiment was conducted at the experimental field of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Bangladesh. The experimental site was located in the center of the Madhupur Tract (AEZ-28) at approximately 24°23´ north latitude and 90°08´ east longitude, having a mean elevation of 8.4 m above sea level. The experimental field is a highland with silty clay soil. The soil conditions were: slightly acidic (pH 6.4), low in organic matter (0.87%), total N of 0.09% and exchangeable K of 0.13 centimol kg^{-1}. The experimental site is in a subtropical zone and has sharp differences in summer and winter temperatures.

2.2. Materials

Twenty distinct and promising selected genotypes of vegetable amaranth were investigated during 2014–2015 and 2015–2016 growing seasons.

2.3. Experiment design, layout, and cultural practices

Vegetable amaranth was sown in a randomized complete block design (RCBD) in triplicate for both years. The unit plot size of each genotype was 1 m^2. The spacing was 20 cm between rows and 5 cm between plants. Recommended fertilizer and compost doses and appropriate cultural practices were maintained. Thinning was performed to maintain appropriate plant density within rows. Weeding and hoeing were performed at 7-day intervals. Day time temperatures during the experimental period ranged from 25 to 38.5°C. Irrigation was provided at 5- to 7-day intervals. For foliage yield, the plants were cut at the base of the stem (ground level).