Amaranth – Perspective as an alternative crop for saline areas

Amaranth (*Amaranthus* spp.), which belongs to the family Amaranthaceae, is an ancient food of the Aztecs and Mayans of Central America, and is now grown in many temperate and tropical regions. The genus Amaranthus comprises about 70 species, of which 40 are edible. All parts of the edible amaranth plant are suitable for eating. Furthermore, amaranth is very nutritional. The leaves are a good source of vitamins and minerals, i.e. leaves contain three times more vitamin A, calcium and niacin (vitamin B_3) than spinach, and 18 times more vitamin A, 13 times more vitamin C, 20 times more calcium and seven times more iron than lettuce (Guillet, 2004). Amaranth leaves show a significant energy value ranging from 27 to 53 kcal/100 g of fresh leaves and high nutrition value - in particular 4-6 g of protein, 0.2-0.6 g of fat and 4-7 g of carbohydrates. As for amaranth grain, it is high in fiber and low in saturated fats, whereby it contains 12% to 17% protein; moreover, Amaranth is an excellent source of lysine, which sets it apart from other grain crops (Kauffman and Weber, 1990).

In India and the Americas, amaranth is most often grown for its seeds, while in Southeast Asia and Africa, amaranth is grown as a leafy vegetable. In the United Arab Emirates (UAE), while *A. hybridus* and *A. caudatus* are occasionally cultivated, three other species namely: *A. albus*, *A. viridis* and *A. graecizans* grow as weeds in gardens and plantations though they are reportedly eaten in other parts of the world (see Mlakar et al. 2010). In recent years, there has been growing interest in Amaranth worldwide due to it being a highly nutritious gluten-free grain with many uses. Similar to other cereals, it can be used as a breakfast cereal and in making crackers, breads, cookies and other flour-based products. Cooked leaves are used as a side dish, in soups and as an ingredient in baby food, pasta, pie, and so forth.

Grain color variation in amaranth

Amaranth grown at ICBA research station in Dubai

Amaranth is a fast-growing crop that is adaptable to a wide range of soils and climates. It is also one of the few C_4 crop* species other than the grasses; thus, it performs well under adverse conditions, especially heat and drought. C_4 plants convert a higher ratio of atmospheric carbon to plant sugars per unit of water lost than those possessing the classical C_3 (Calvin cycle) pathway. In view of its tolerance to major abiotic stresses, amaranth has now emerged as a major climate resilient vegetable crop that not only fights climate change, but also fulfills the growing nutritional needs of human beings.

Heat and salinity are known to be the two major abiotic stresses impacting agricultural production in the Arabian Peninsula and elsewhere. Amaranth is reported to be moderately salt tolerant and compares well with other vegetable crops such as cowpea and mustard (Omami et al. 2006). However, most of the studies on salinity tolerance in Amaranth have been in pots under controlled greenhouse conditions and there is limited information on its performance under saline field conditions. Hence, the International Center for Biosaline Agriculture (ICBA) recently evaluated the performance of a few selected genotypes of two *Amaranthus* spp. (*A. cruentus* and *A. hypochondriacus*) under saline field conditions in Dubai.

Five genotypes (four of *A. cruentus* and one of *A. hypochondriacus*) previously selected for high yield potential from a set of 50 germplasm accessions received from the United States Department of Agriculture (USDA) were studied in a field trial laid out in a Randomized Block Design (RBD) with three replications. The irrigation treatments consisted of a control (EC_w 0.2) and three salinity levels with EC_w equivalent to 5, 10 and 15 dS m^{-1} obtained by mixing saline ground water with fresh water. Sowing was done in Mid-November. Each plot had four rows of 2.5 m and the distance between rows and between plants within each row were 50 and 25 cm, respectively. The plants were irrigated using the drip-system. Standard agronomic data were recorded from five randomly selected plants from the two middle rows within each plot. Analysis of variance was used to assess the effect of salinity, with the limit for statistical significance set at $p=0.05$.

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* *The terms C_4 and C_3 refer to the different pathways that plants use to capture carbon dioxide during photosynthesis. C_3 plants use the enzyme ribulosodiphosphatcarboxylase to fix CO_2 and the first product created is a 3-carbon molecule phosphoglycerate, while C_4 plants use phosphoenolpyruvate carboxylase to fix CO_2 and the primary product of photosynthesis is oxaloacetic acid.*

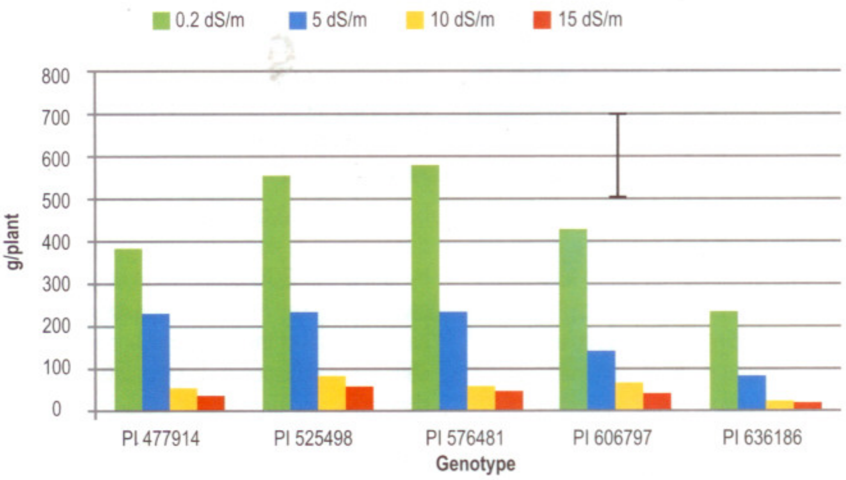

Figure 1: *Effect of salinity on green biomass production in five amaranth genotypes. The error bar represent the least significant difference (LSD) at P = 0.05.*

Analysis of the data showed that amaranth has good adaptation to the UAE environment, characterized by the hyper arid climatic conditions with limited supply of irrigation water and nutrient-poor sandy soils with low water holding capacity and high alkalinity. Current studies however indicate that amaranth performs well as a winter crop and produces high biomass and seed yields with non-saline irrigation water. Thus, based on a density of 16 plants/m^2, the estimated above-ground biomass yield in the non-saline control treatment was 69,280 kg/ha–much higher than the maximum reported yield of 49,000 kg/ha from favorable environments (see Mlakar et al. 2010). Similarly, the seed yield of 3,696 kg/ha obtained with non-saline water was close to the maximum reported yields of 3,800 kg/ha from Europe. Salinity stress however, significantly affected growth and productivity and the differences among genotypes were also highly significant (see Figures 1 & 2). However, the interaction between genotypes and salinity levels were not significant indicating that the response of the different genotypes to increasing salinity stress was about the same. Averaged over genotypes, increase in salinity from 0.2 dS/m (control) to 5 dS/m has decreased the mean plant height by 26%, stem thickness by 18%, number of branches by 28%, fresh biomass yield by 58% and seed yield by 79%. Further increase in salinity to 10 dS/m decreased plant height by as much as 52%, stem thickness by 46%, number of branches by 37%, fresh biomass yield by 87% and seed yield by 88%, compared to the control. In terms of genotypes, PI 525498 and PI 576481 produced the maximum biomass yields at all salinity levels. For seed yield, averaged over salinities, PI 576481 produced the maximum of 13.2 g/plant followed by PI 4477914 (9.2 g/plant) and PI636186 (8.6 g/plant).

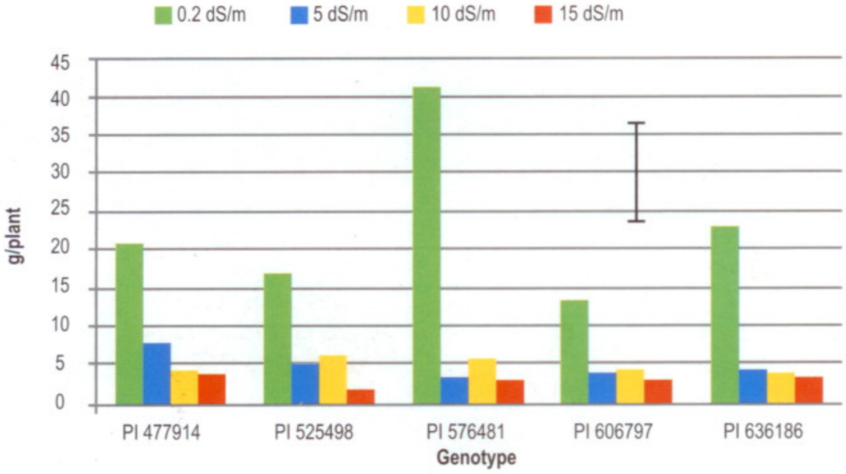

Figure 2: *Effect of salinity on seed yield of five amaranth genotypes. The error bar represent the least significant difference (LSD) at P = 0.05.*

In conclusion, results from this study showed that salt stress has more detrimental effect on seed yield than on the biomass yield and thus it is uneconomical to cultivate Amaranth in areas with saline water for irrigation. This is in contrast to the previous observations that mild to moderate salinity has no adverse effect on yield (see Omami et al. 2006; Costa et al. 2008) but as the number of genotypes evaluated in this study was small, further work on a broader range of genotypes is recommended to confirm this observation. Nonetheless, amaranth is still a promising new crop for non-saline areas that may prove instrumental in addressing the food security challenges of the future.

References

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