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Assessment of tolerance to salt stress in Kenyan tomato germplasm

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Summary

Tomato is an important vegetable crop in Kenya and the development of salt tolerant cultivars would enhance its productivity in the vast marginal areas of the country. This study was aimed at determining the magnitude of genotypic variability for salt tolerance in the Kenyan tomato germplasm. Pot experiments with 22 landraces and 9 market cultivars were laid out as a two and four replicate split-plot design in glasshouse in Experiments 1 and 2, respectively. Salt treatments in Experiment 1 were 0 and 5 g NaCl kg^{-1} resulting into 0.5 and 9.1 dS m^{-1} of the soil saturation extracts, respectively. In Experiment 2 the treatments were 0, 4, and 8 g NaCl kg^{-1} soil corresponding to 0.5, 7.4, and 14.2 dS m^{-1}, respectively. Data were recorded on agronomic and biochemical parameters. The germplasm showed large variation for salt tolerance. Fruit and seed production at soil salinity of 14.2 dS m^{-1} demonstrated that these tomatoes are fairly tolerant of NaCl. Osmotic adjustment was achieved by higher fruit electrical conductivity, brix and total titratable acidity. Low and high contents of K^+, Ca^{2+} and Mg^{2+} within tomato tissues and soil, respectively, under salt treatment, confirmed competition and antagonism involving Na^+ and these cations. Low Na^+ and Cl^- contents in the fruit at 7.4 dS m^{-1} revealed their exclusion and ensured production of physiologically normal seeds and nutritionally healthy fruits. Two landraces 'Chwerotonglo' and 'Nyanyandogo' were identified as salt tolerant. Comparatively, the market cultivars showed superior fruit yields despite their susceptibility to salinity. Accordingly, tolerance of landraces in combination with superior yields of the market cultivars is suitable for tomato improvement for salt tolerance.

Introduction

The rapid human population growth rate in Kenya (3.9%) and the continued scarcity of arable land have forced quite a large proportion of the population to cultivate the more marginal areas of the country. However, suitable crop varieties for this large proportion of the country (80%) with evapotranspiration always exceeding the precipitation rate (Biamah et al., 1994), are desperately lacking. Furthermore, technology for the exploitation of this vast marginal area is highly limited given the restricted economic potential. In order to meet both increased production and self-sufficiency in food, there is an urgent need for breeding strategies and packages which would address the use of locally adapted plant germplasm.

Breeding tolerant crop varieties for salt stress is considered to be an effective energy saving approach in bringing a greater portion of semiarid and arid land into productive agriculture. Furthermore, genetic advancement in salt tolerance is a fundamental strategy in increasing agricultural production and stabilising productivity (Jones, 1986). Several technical options are available for the management of saline soils, for example irrigation (Rush & Epstein, 1976). However, the question of the quality, cost and availability of irrigation water remains largely unresolved. Use of higher yielding and more salt tolerating crop species

would be expected to constitute a more environmentally undisturbing, ecologically sound and economically affordable approach to bringing this land into productive and sustainable agricultural systems. An integrated approach including both breeding for tolerant varieties and soil ameliorative techniques, seems a more viable avenue in the utilization of the saline hit tropics for increased food production.

The objectives of this study were to assess Kenyan tomato germplasm for their potential in tolerating moderate soil salinity and to advise on the possible use of this genetic material for future tomato breeding work aimed at expanding cultivation of the vast marginal areas of this country. We have also investigated ion accumulation in the different tomato tissues in order to explain possible physiological reasons for variation in salt tolerance. The evolutionary and nutritional aspects of salt tolerant tomato landraces also formed a central investigation in this study. Both morphological and biochemical markers were scored on whole tomato plants to study responses to salt. The use of morphological characterisation in studying salt tolerance is widely reported in many crop species (Foolad & Jones, 1993; Asin et al., 1993). The high susceptibility of morphological markers to environmental variation renders this approach by itself less important and reliable in screening for salt tolerance. The development of salt tolerant tomatoes may not be based solely on morphological adaptations particularly with regard to the current quest of better quality hybrids.

Materials and methods

Tomato (*Lycopersicon esculentum*) genotypes (Table 1) collected from different parts of Kenya as already detailed by Agong & Schittenhelm (1993) were used in this study. The germplasm comprised of 22 landraces and 9 market cultivars. The tomato landraces were randomly and representatively sampled in sites of differential soil electrical conductivities (see Table 1). The nine market cultivars are widely grown in the country and were included for studying to what extent they differ from landraces with respect to salt tolerance.

The investigations were conducted under glasshouse conditions at the Institute of Crop Science of Federal Agricultural Research Centre (FAL) in Braunschweig-Völkenrode. Seeds were initially germinated in organic enriched compost soil with a thin sand cover to facilitate aeration, in open plastic germination trays. The average glasshouse temperatures were 15 and 25 °C at night and day, respectively, whereas the relative humidity was maintained at 70%. Supplemental lighting of 7000 Lux for 6 hours was provided to the seedlings during the months of February and March.

Four weeks after emergence, the seedlings were transplanted into 12 cm plastic pots. The two months old seedlings were later singly transplanted into a 26 cm painted metallic pot filled with 5 kg soil:peat (2:1 on volume basis) homogenous mixture. The salt treatments in Experiment 1 included 0 (control) and 5 g NaCl kg^{-1} soil giving rise to electrical conductivities (EC) of soil saturation extract of 0.5 and 9.1 dS m^{-1}, respectively. Soil was wetted to 75% water available capacity till end of harvest.

The transplanted plants were transferred to the glasshouse. The experimental design used was a two-replicate completely randomised block with split-plot arrangement where the population and salt formed the main and sub plots, respectively. Single plants per plot, three per treatment from each one of the 31 genotypes, were studied. Plants were supplied with 7 g of complete compound fertiliser [Nitrophoska 12:12:17 (12:6) corresponding to N:P_2O_5:K_2O: (MgO:CaO), respectively] in four split (1 g immediately after transplanting and 2 g every other two weeks). After seven weeks of salt treatment, the leached salt collected underneath experimental pots was rinsed with 100 ml of the irrigation water which was then re-supplied to the plants.

At the final transplanting and harvest, salt treated and control soils were sampled (about 50 g of the soil) then air dried till they attained an average of 94% dry matter content before being shaken to pass through a 2 mm diameter sieve. The homogenous soil samples, 20 g in each case, were weighed and used for mineral content, electrical conductivity and pH determination as outlined by Westerman (1990). The soil pH was determined using pH Meter (Orion Ross 3500 of Beckman) from which 20 g was thoroughly mixed with 100 ml 0.01 M $CaCl_2$ by stirring, and left to settle for one hour. The EC of the soil saturation extract was determined on a conductivity meter (LF 2000 WTW) from the same soil saturation extract used for the elemental contents analysis.

The plants were harvested at bright red fruit maturity. The fruits from individual plants were continuously harvested from the date of the first bright red ripened fruit to a maximum of four weeks. At maturity the fruit and vegetative parameters plant height (cm), fruit number, fruit width (cm), fresh and dry matter fruit yields (g), dry matter shoot and root yields (g) were determined. At the same time, the fruit juice was extracted