Chapter 43
Towards the Development of Salt-Tolerant Potato

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ABSTRACT

Soil salinity is a major constrain to crop production and climate change accelerates it. It reduces plant water potential, causes ion imbalance, reduce plant growth and productivity, and eventually leads to death of the plant. This is the case in potato. However, potato has coping strategies such as accumulation of proline, an osmoregulator and osmoprotector. In addition, leaching of salts below the root zone is preferred, exogenous application of ascorbic acid and growth hormones are practiced to combat salinity. Breeding and genetic engineering also play key roles in salinity management of potato. Varieties such as: Amisk, BelRus, Bintje, Onaway, Sierra, and Tobique were tolerant in North America, variety Cara in Egypt, Sumi in Korea and varieties Vivaldi and Almera in Mediterranean region. Transgenic lines of Kennebec variety, lines S2 and M48 also proved tolerance due to transcription factor MYB4 encoded by rice Osmyb4 gene.

CLIMATE CHANGE AND SALINITY

Climate change is observed and predicted as the single-most event that is changing and will continue to change the cause of the world's future. It is a major challenge to agriculture. As the climate 'forcing mechanisms' shape climate through processes such as: variation in solar radiation, continental drifts and changes in greenhouse gas concentration, they encourage increase in global temperatures, melting of ice-caps, rising ocean levels, unpredictable and variable amount of rainfall, more cyclones and heat waves, and increased desertification (Abumhadi et al., 2012). There are projections of increase in precipitation in winters and overall decrease in the tropics and sub-tropics (IPCC, 2007). A decrease in precipitation means a decrease in water availability and increase in evaporative demand due to rising temperatures (Vicente-Serrano et al., 2014; Wang et al., 2012). Increase in temperatures enhance evapotranspiration especially in arid and semi-arid regions. In the event that evapotranspiration exceeds precipitation, salts

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accumulate on the soil surface (Sivakumar, 2007). This has an implication on irrigation requirement (Doll & Siebert, 2002). The decrease in precipitation causes demand for more irrigation (McDonald & Girvetz, 2013; Riediger et al., 2014) even though, in arid and semi-arid regions water available for irrigation is saline (Levy et al., 2013). This consequently exacerbates soil salinity. Additionally, a rise in sea-level due to global warming threatens low-lying coastal agricultural lands – this rise leads to flooding by oceans' saline water and salinization of groundwater (Gornall et al., 2010). Grenfell et al., (2016) predicts that 125 to 175 years from 2010 more wetlands will experience frequent flooding with saltwater. Flooding of the coastal area with saline water has a far-reaching impact. Indeed, this salt incursion reduces dissolved organic carbon in the coastal wetlands from 40 mg l^{-1} to 18 mg l^{-1} (Ardón et al., 2016). Furthermore, increased salinity in the coastal wetlands will cause accumulation of less stable carbon (Williams & Rosenheim, 2015), reduction in marsh biodiversity, and lead to development of more salt tolerant plant communities (Grenfell et al., 2016).

SOIL SALINITY

Salinity is a phenomenon that is causing major havoc in agricultural production (Figure 1) (D'Odorico et al., 2013). The earliest salinity effect in agriculture was recorded around 2400 to 1700 BC in the ancient Mesopotamia, currently Southern Iraq (Jacobsen & Adams, 1958). 6% of arable land around the world is affected by salinity or sodicity, this is 800 million hectares (FAO, 2009). Salt-affected soils have high levels of dissolved salts and or high concentrations of adsorbed sodium ions (Yadav et al., 2011). These soils are categorized into three classes: First are the saline soils having an electrical conductivity (EC) of over 4 dS m^{-1} and sodium adsorption ratio (SAR) of less than 13 or exchangeable sodium percentage (ESP) that is below 15. The second category are sodic soils which are characterized by an EC of less than 4 dS m^{-1}, SAR or ESP above 13 and 15 respectively. Finally, the saline-sodic soils, whose EC, SAR, or ESP are above 4 dS m^{-1}, 13 and 15 accordingly (United States Salinity Laboratory, 1954).

Figure 1. Global distribution of saline soils using data from the Harmonized World Soil Database. Salinity on the map is represented by electrical conductivity (dS m^{-1}) and the coloring schemes illustrate different ranges in soil salinity corresponding to the relative degree to which soil salinity constrains plant productivity
Source: D'Odorico et al., (2013)