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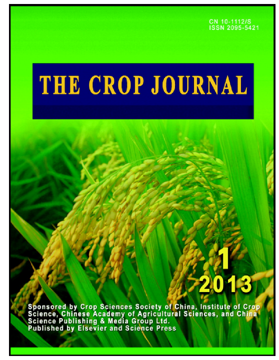

Plant salt tolerance and Na+ sensing and transport

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Review

Plant salt tolerance and Na^+ sensing and transport

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Abstract: Salinity is a global challenge to agricultural production. Understanding Na^+ sensing and transport in plants under salt stress will be of benefit for breeding robustly salt-tolerant crop species. In this review, first, possible salt stress sensor candidates and the root meristem zone as a tissue harboring salt stress-sensing components are proposed. Then, the importance of Na^+ exclusion and vacuolar Na^+ sequestration in plant overall salt tolerance are highlighted. Other Na^+ regulation processes, including xylem Na^+ loading and unloading, phloem Na^+ recirculation, and Na^+ secretion, are discussed and summarized. Along with a summary of Na^+ transporters and channels, the molecular regulation of Na^+ transporters and channels in response to salt stress is discussed. Finally, some largely neglected issues in plant salt stress tolerance, including Na^+ concentration in cytosol and the role of Na^+ as a nutrient, are reviewed and discussed.

Keywords: Channels; Na^+ sensing; Na^+ transport; Plant salt tolerance; Transporters

1 Introduction

Sodium constitutes the sixth most abundant element on earth [1], and sodium salts dominate in many saline soils of the world [2]. The current progressive increase in soil salinization may result in a ~30% loss of the arable land within the next 25 years [3]. To meet the projected food demand of 9.3 billion people by 2050, global agricultural production must be increased by 60% from its 2005–2007 levels [4]. This urgent need requires a large effort to improve agricultural production. One feasible way to cope with this challenge is to breed robustly salt-tolerant crops. Understanding the mechanisms underlying plant salt tolerance would be of benefit for breeding such crops and mitigating future food shortages.

Na^+ is generally not essential for plants. The similarity of the hydrated ionic radii of Na^+ and K^+ leads to Na^+ toxicity in plants under salt stress [5]. Accumulation of high Na^+ in the cytosol can not only cause K^+ deficiency and thus disrupt various enzymatic processes, but also impose an energetic burden on the cell owing to the requirement of organic solute synthesis to compensate for the export of Na^+ for osmotic adjustment [6]. More than 50 enzymes are activated by K^+, which cannot be substituted with Na^+ [7]. Also, oxidative stress is always accompanied by salt stress in plants [8]. Thus, understanding how Na^+ is sensed and transported in plants under saline conditions could help researchers or breeders breed crops with robust salt tolerance.

The present review is focused mainly on how plants sense Na^+ and control its transport under salt stress. The molecular identity of transporters and channels involved in Na^+ transport and its molecular regulation in response to salt stress are discussed.

2 Na^+ as an issue

Our earth is a salty planet [9, 10]. Saline soils cover 3.1% (397 million ha) of the total land area of the world [11]. High concentrations of salts in soils account for large decreases in the yields of a wide variety of crops worldwide

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