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SUMMARY OF DOCTORAL THESIS

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Title:

Mechanisms of salt tolerance and their physiological implications on growth of common bean (*Phaseolus vulgaris* L.)

(インゲンマメの塩耐性の生理機構と成長との関係)

Salinity is one of the major factors affecting agricultural productivity worldwide. Common bean is a major vegetable crop where 20 to 30% of the bean-production areas in the Middle East are affected by soil salinity. Under such a situation, yield is expected to be low as the common bean is extremely sensitive to salinity and suffers yield losses at soil salinity levels less than 2 dSm^{-1}. To evaluate the physiological and morphological responses of locally adapted Sudanese common bean varieties to salinity stress, five cultivars: Bassbeer, Beladi, Giza 3, HRS 516 and RO21 were screened at varying salinity level. The effect of salinity stress on the five cultivars of common bean were initially evaluated on a sand/peat medium with different salinity levels (0, 50 and 100 mM NaCl) applied 3 weeks after germination for a duration of 10 days. Salinity had adverse effects not only on the biomass yield, and relative growth rate (RGR_t), but also on other morphological parameters such as plant height, number of leaves, root length and shoot/root weight ratio. Photosynthesis, transpiration rate and stomatal conductance were adversely affected in all cultivars. Leaf osmotic potential and leaf turgor varied significantly among cultivars and salt levels. The decrease in leaf osmotic potential of the other cultivars was attributed to an increase in salt level. Even though leaf osmotic potential decreased in the previously tested cultivars, HRS 516 maintained a relatively constant potential under saline conditions. At 100 mM NaCl, however, RO21 exhibited a lower leaf osmotic potential, four-folds lower than HRS516. This could be explained from the fact that during stress, carbon allocation, osmotic adjustment and accumulation of soluble sugars compete with other sinks and can affect growth. Generally, glycophytic as well as halophytic species adjust to high salt concentrations by lowering tissue osmotic potential with an increase in inorganic ions from external solution and/or compatible solutes. Furthermore, osmotic adjustment helps to maintain shoot functioning. It was also observed that under high salinity stress (100 mM NaCl), common bean tend to suffer reduction in root biomass and

damage in the root tip and might induce structural changes in bean roots, as well as leakage of ions due to alteration of the cell membranes. In the last phase of the study, physiological mechanisms of salt tolerance and their implications on growth of two common bean cultivars (HRS 516 'salt tolerant' and RO21 salt 'susceptible') were also studied following initial screening. We investigated the effects of salinity stress on biomass production, photosynthesis, water relations, and activity of antioxidant enzymes in two cultivars of common bean (HRS 516 and RO21). Seedlings were raised in nutrient solution supplemented with increasing concentrations of sodium chloride (NaCl) at 0, 50, and 100 mM. After 10 days of salinity treatment, the plants were sampled to determine the enzyme activity, protein content and dry biomass. Plant biomass and activities of most antioxidant enzymes were adversely affected by salinity stress. The cultivar, HRS 516 accumulated less Na^+ than RO21. The suggests that HRS 516 is more resistant cultivar because of its ability to exclude Na^+ from shoot, and that osmotic adjustment helps to maintain shoot functioning. Under salinity, superoxide dismutase (SOD) enzyme activity increased 3 folds in both bean cultivars (HRS 516 and RO21) compared to other antioxidants (APX, CAT and GR). Disparity in antioxidant enzyme response under salinity stress show that legume-producing ureides (uricase II) might also be involved in the mechanisms salinity, a pathway different from that of ascorbate-glutathione cycle.

In conclusion, the results reported indicate that the response to salinity stress in common bean is biphasic. During the initial hours of exposure to salinity stress, a strong and rapid change in leaf water potential, and antioxidant enzymes, stomatal closure and an amelioration of root water transport properties allow plants to rehydrate and regain turgor at moderate salinity (50 mM NaCl). Consequently, biomass (shoot and root weight), net photosynthesis are adversely decreased with a marked increase in antioxidant enzyme content, especially SOD. As in detoxifying process, SOD is the first defense line in plant response to oxidative stress as it converts superoxide radicals to H_2O_2; therefore it could be used together with other key physiological traits (biomass, photosynthetic apparatuses, water content and ion accumulation) as biomakers for oxidative stress.