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Grain Shape as a Predictor of Salt Tolerance in Sunflower

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ABSTRACT

To determine whether sunflower (*Helianthus annuus* L.) grain shape should be considered as a predictor of salt tolerance, seeds of three grain shapes, namely long seeds (DC6009 and RH3146 with a width-length ratio [WLR] of 0.39), long ovate seeds (SH909 and 135 with a WLR of 0.49) and broadly ovoid seeds (RH118 with a WLR of 0.61) were exposed to 0, 1000, and 2000 mg L^{-1} NaCl for 30 d. Increases in the WLR increased the 100-seed weight and kernel/hull rate (KHR) but decreased the water absorption rate (WAR). A level of 2000 mg L^{-1} NaCl delayed the seed mean germination time (MGT), reduced the germination percentage (GP) and germination index (GI) and caused shorter root length (RL). A level of 1000 mg L^{-1} NaCl improved the GP and GI compared with the no NaCl-stressed control with the exception of the long ovate seeds. RL decreased with increasing NaCl levels, and plants with broadly ovoid seeds had longer roots than those with other shapes. The activities of superoxide dismutase (SOD), catalase (CAT), and peroxidase (POD) were lower in the NaCl-stressed plants than the controls. The malondialdehyde (MDA) contents increased with the NaCl levels in all cultivars. The broadly ovoid seeds exhibited the greatest enzyme activities and the highest net photosynthetic rate (Pn) at both NaCl levels. Based on emergence, early seedling growth and physiological characteristics, the long ovate seeds had a higher salt tolerance than those of the other two shapes, followed by those with long seeds.

Core Ideas

- Low dose of NaCl generally improved the germination of most cultivars.
- Broadly ovoid seeds exhibited the greatest enzyme activities at both NaCl levels and grain shapes.
- Sunflowers with long-ovate seeds perform better when subjected to slightly salinized land.

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Soil salinity is widely reported to be a serious agricultural problem and is becoming a major constraint in irrigation expansion in humid, arid, and semiarid regions of the world. China is one of the countries that suffers from salt stress or potential degradation due to secondary salt stress. Particularly in northern China, nearly 100 million hectares of cropland suffer from salinization (Rozelle et al., 1997). Nevertheless, this salt-affected area gradually increases within a rising groundwater table due to unreasonable irrigation and insufficient drainage. The severely salt-affected land may eventually become completely unproductive and abandoned if the salt problem cannot be immediately and effectively resolved (Wu et al., 2008).

A given mass of salt can reduce the rate of germination, restrict the water uptake by plant roots, retard plant growth due to ion toxicity and create a nutrient imbalance (Marschner, 1995). Furthermore, secondary stresses, such as oxidative damage, often occur as a consequence of these primary effects. Thus, the salt tolerance mechanisms in natural ecotypes appear to be complex (Ashraf et al., 1987). Previous studies reported that soil salt reduces plant growth through the osmotic effect in the first growth phase (Munns, 1993; Saqib et al., 2006), particularly in infancy (Munns and Termaat, 1986). If possible, breeding for salt tolerance in crop species is an economical approach to overcoming the soil salt problem.

Sunflowers are considered to be moderately salt tolerant (Shi and Sheng, 2005) and have been widely cultivated in salinity-affected areas worldwide. Additionally, these plants are becoming one of the most important oil seed and cash crops because it is a popular snack in the food industry. Salt is a major constraint in sunflower cultivation because rainfall is not sufficient to leach salts from the root zone and evapotranspiration tends to exceed rainfall (Nolan et al., 2007). In this scenario, farmers constantly select out new cultivars with higher salt tolerance ability via physiological, biochemical, and agronomic techniques. Many varieties of sunflower seeds with different characteristics thus arise.

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Abbreviations: CAT, catalase; GI, germination index; GP, germination percentage; KHR, kernel/hull rate; MDA, malondialdehyde; MGT, mean germination time; Pn, net photosynthetic rate; POD, peroxidase; RL, root length; SOD, superoxide dismutase; WAR, water absorption rate; WLR, width-length ratio.