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A better understanding of the complex interaction between plant and environment is required to improve plant yield stability over different locations. For this purpose, we studied the relationships among productivity, root architecture and its physiological function in nutrient acquisition. Root architecture parameters, glucose and fructose concentration in the root tip and sulfate uptake rate were evaluated in 18 sugar beet genotypes characterized by different sugar production ability. Significant genetic differences were observed in total root length, surface area, number of root tips, glucose and fructose concentration in the root tip and sulfate uptake rate after deprivation. Such traits were significantly correlated with root and sugar yield. These results demonstrate the existence of a strict association between morphological and physiological root traits and their relationships with productivity. These coordinated actions at the level of the whole root system contribute to explain plant adaptation to multiple environmental stresses.