The Role of Boron in Nitrogen Fixation in Legumes

Most of the plants, especially legumes, convert the stable nitrogen (N_2) in the atmosphere, which cannot be used directly, into a usable form by biologically reducing it because of the nitrogenase enzyme they have. This process, known as biological nitrogen fixation, starts with a symbiotic relationship between the rhizobium bacteria and the roots through nodules in legumes. In this way, legumes provide very high amounts of nitrogen from the air and producers are prevented from making unnecessary extra synthetic nitrogen fertilization.

There are research findings showing that boron nutrition of plants plays a major role in the mentioned symbiotic relationship. For example, it is suggested that boron facilitates the establishment of a symbiotic relationship between the two organisms by stabilizing the membrane system between the plant and symbiotic bacteria and ensuring the continuity of stability in legumes fed with sufficient boron. In a study, the decrease in the nitrogen-fixing capacity of pea plants under boron deficiency was attributed to the decrease in nodule development and nitrogenase enzyme activity in the roots, as well as the degeneration in the structure of the peribacteroid membranes, which has a decisive role in nutrient transport between bacteria and plants.

It has been claimed that boron has another different role in nitrogen fixation. Nitrogenase enzyme involved in nitrogen fixation is hypersensitive to oxygen, and boron has been found to reduce this sensitivity. According to the results of some research, boron plays an important role in keeping the bacterial heterocyst cells in which the nitrogen fixation process takes place in an oxygen-impermeable state. Thus, boron plays a protective role against the toxic oxygen derivatives such as hydrogen peroxide, to which nitrogen-fixing bacteria are very sensitive.

As a result of the said mechanisms, it is reported that the nitrogen-fixing capacity of the roots of many different legume plants decreases under boron deficiency. In soybean plant, it was found that boron application increased nitrogenase activity and nodule weight, and the nitrogen content of the plant increased in the same way. In addition, it has been reported that nitrogenase enzyme activity remains at higher levels under stress conditions such as salinity and drought with a good boron nutrition. It is reported that this known positive effect of boron on the nitrogen-fixing nitrogenase enzyme activity is very specific. For example, only two hours of boron starvation had no effect on the photosynthesis or respiration in the plant, but led to a significant reduction in nitrogenase activity. The fact that the nodules have up to four times higher boron concentration compared to the roots reveals that boron has a very critical role in nodule formation and function.

The results show that boron plays an important role in the effective utilization of nitrogen from the air by plants by improving the symbiotic relationship between the nitrogen-fixing bacteria and the root on the one hand, and the biological nitrogen-fixing process through nitrogenase enzyme activity, on the other.

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