Enhancing Water Stress Tolerance in Soybeans Through Phytoglobin Manipulations

Phytoglobin levels can be used as a rapid screen to select soybean varieties that are tolerant to excess moisture and drought stress.

SOYBEANS GROWN IN Manitoba may be subject to flooding and/or drought in any given year. With the high proportion of clay soils across the province, water levels tend to recede slowly and can inflict yield loss if excess moisture is prolonged. However, soybeans also require 16–20 inches of water throughout the growing season and can suffer if there is insufficient moisture, especially from late July through August when they need it most.

Having soybean varieties that could tolerate both flooding and drought stress would be a real advantage in Manitoba. Research on plant proteins called phytoglobins (Pgbs) and their role in plant tolerance to environmental stressors may be one way to achieve this.

Pgbs are like animal hemoglobins that bind to oxygen and remove nitric oxide, which damages plant cells and tissue if left to accumulate. Nitric oxide build-up is a plant response linked to both flood and drought conditions. This suggests the potential for Pgbs to improve tolerance to both types of water stress.

The goals of this research were to:

1. screen commercially available soybean varieties for their ability to tolerate water stress and correlate their ability to Pgb level, and
2. assess water stress tolerance of transgenic plants that have experimentally increased or decreased Pgb levels.

In this study, the behaviour of 20 commercial soybean varieties to submergence and waterlogging was characterized. This has helped establish the relationship between Pgb expression level and tolerance to water stress. Natural variations of Pgb can be exploited to select varieties that cope with both types of stress.

Transgenic soybean varieties were successfully developed that either over-produce or under-produce Pgb. From this work, we can confirm that Pgb levels directly correlate with the soybean plant's ability to recover from excess moisture.

Overproduction of Pgb is desirable for improved plant tolerance to water stress. Plants that overproduced Pgb grew better, had a higher photosynthesis rate and produced more adventitious roots—all signs of recovery from moisture stress (Figure 1). Preliminary research has shown that seed number per plant is also enhanced by the overproduction of Pgb.

In addition to recovery from stress, high levels of Pgb in root tissues help protect cells from dying under moisture stress. Plants with high Pgb can then initiate more root growth to recover, compared to plants with low Pgb that slow their root growth in response to stress.

Further studies were initiated at the end of this project to test the potential of using phytoglobin as a powerful molecular marker to select soybean varieties that are tolerant to flooding and waterlogging.

Through either traditional plant breeding techniques or modern gene engineering and editing, the results of this work can be applied to improve flooding and/or drought tolerance in commercial soybean production in the Canadian prairies.

Figure 1. Soybean plant recovery after submergence showing tolerant (left) and susceptible plants (right).

PRINCIPAL INVESTIGATOR Claudio Stasolla, University of Manitoba

MPSG INVESTMENT $96,000

CO-FUNDERS Mitacs, Grain Farmers of Ontario (GFO)

DURATION 3 years