Evaluation of soybean breeding lines for iron deficiency resistance

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Summary: Soybean iron deficiency chlorosis (IDC) is a common stress in commercial production especially under high pH, wet, poorly aerated and cool soil conditions. With the funding from MPSG, 62 advanced soybean breeding lines from AAFC-ECORC and 160 germplasm materials were evaluated at Emerson in last three years. Due to the dry field conditions, no significant chlorosis occurred in 2012. However, significant variation was observed in the lines tested in 2013 and 2014. The advanced breeding lines generally showed good resistance to IDC, indicating genetic improvement though breeding selections. Resistant and susceptible materials were identified for use in breeding and genetic research.

Background: The soybean cultivars grown in Manitoba require early-maturity and high yield potential. The breeding efforts for such early-maturing cultivars are often limited by the lack of genetic materials. Soybean is marketed worldwide for human consumption and animal feed, for its high content of protein and oil, and other nutrients such as isoflavones. Soybean can be categorized into different maturity groups, according to the zone and heat unit it grows in. Soybean cultivars can be classified as conventional (non-GMO) and GMO (genetically modified Round-up Ready) cultivars. While the GMO soybean cultivars dominate world acreage for its advantages in weed control and low costs of production, the conventional soybeans still occupy significant markets such as in European countries and Japan, especially as specialty food grade beans. Selection of elite breeding materials with adaptation to Manitoba is necessary for both GMO and conventional cultivar development.

Soil is generally rich in iron content. However, when soil PH is high (greater than 7.5) iron becomes unavailable for soybean plants to absorb. Iron is an essential mineral for plant to synthesize chlorophyll which is the basic unit for photosynthesis. The lack of chlorophyll results in soybean plant stress symptoms known as chlorosis. Iron deficiency also causes reduced nodulation and nitrogen fixation. Severe IDC causes significant yield reduction. Previous research has shown that development of resistant cultivars and breeding lines are the most efficient way to overcome the IDC in soybean. The resistant breeding lines identified from this project will provide much-needed early-maturing materials and germplasm for breeding and production in Manitoba.

Research Objective: To evaluate advanced soybean breeding lines developed at AAFC_ECORC and early-maturing germplasm materials for resistance to iron deficiency chlorosis for use in cultivar development.

Experimental Design: In this experiment, advanced breeding lines developed at the AAFC-ECORC were evaluated in four replications at Emerson. Emerson site was chosen for the test was because it is near the Red River, and has optimal conditions for IDC to occur. Early-maturing soybean germplasm (160 accessions) was also included with three replications in the test. Each line was rated at the 3-8 trifoliate growth stage on a scale of 1-5: 1 = no chlorosis and 5 = very severe chlorosis or dead plants.

Results and Discussion: In 2012, 16 ECORC lines and 160 germplasm materials were grown. However, the water level was low in the Red River and the growing season was generally dry, very little IDC symptoms were observed among the entries.

In 2013, the wet and cool growing conditions favored the development of IDC symptoms in the test plots. Most symptoms appeared at the early growth stages (3-8 trifoliates). Many lines were able to recover to some degree at later growth stages from the earlier symptoms, however, some lines were identified with stunted plant growth leading to severe yield loss. The 30 ECORC breeding lines were generally healthy (IDC < 2.5) and yielded well in the evaluation, suggesting the effective genetic improvement through selections. Most lines showed no or only slight symptoms. Meanwhile, the 160 germplasm materials had significant variation with IDC ranging from 1 to 4.5. Eighteen lines were tolerant (IDC < 2.5) and 68 lines were susceptible (IDC >=3). Due to the heterogeneous field conditions, variation was observed among replications. However, there are 16 lines which appeared to be more consistently resistant. The identified materials were used in crossing for genetic improvement of IDC resistance.

IDC resistant line flanked by susceptible materials in the test conducted at Emerson in 2013

In 2014, the growing season was generally wet but the IDC symptoms were not as severe as in 2013. The 16 ECORC lines were generally resistant to IDC with the rating ranging from 1 to 1.5. Among the 160 germplasm lines, the IDC ranged from 1 to 3.

In summary, ECORC breeding lines were generally tolerant to IDC, suggesting genetic improvement through selections. Sixteen germplasm materials appeared to be consistently tolerant to IDC, and 68 lines were identified to be highly susceptible. However, due to the heterogeneous field conditions, inconsistency was observed in the soybean materials evaluated in Emerson. Especially in 2011, no symptoms were observed due to the dry weather. Future screening of soybean IDC under controlled conditions may be needed.

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