Fine Mapping of Iron Deficiency Chlorosis and Canopy Wilt Tolerance QTL from the Soybean Landrace 'Fiskeby III'

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Introduction:

Iron deficiency chlorosis(IDC) in soybeans can add up to ~$260 million in lost yield annually (Peiffer et al. 2012). With such tremendous yield and profit losses as a result of this abiotic stress, the University of Minnesota (including soil scientists, agronomists, and breeders) has put forth efforts in an attempt to combat this stress. The problematic zones for IDC stress in Minnesota include parts of south central, southwest, west central, and northwest Minnesota. Soils in these zones typically have a pH greater than 8 as a result of bicarbonate release in the calcareous soils. The soybeans grown on these soils become chlorotic as a result of iron becoming unavailable for plant uptake In a study comparing the effects of iron foliar spray, treating seeds with iron, and cultivar selection, it has been concluded that cultivar selection remains the most effective method in controlling IDC in soybean (Goos & Johnson (2000)).

Canopy wilt due to drought is another major abiotic stress in soybean. In various greenhouse studies, limited water availability has resulted in early senescence, seed size reduction, and reduced pod set all resulting in lower yield. The results of these greenhouse studies can be translated to yield data across the United States, which shows a dramatic difference in production of dryland versus irrigated soybeans. Specht et al. (1999) identified water limitations as a major obstacle in soybean genetic improvement. While some exotic germplasm has been found to aid southern soybean breeding programs in establishing drought resistant varieties (Carter et al. 1999), very little work has been done for the northern United States.

'Fiskeby III' (PI 438471) was identified as a landrace resistant to many abiotic stresses, including drought, iron deficiency, salt, aluminum toxicity, and ozone (Burkey & Carter 2009, Holmberg 1973). In the summer of 2006, 'Fiskeby III' was crossed to 'Mandarin (Ottawa)' (PI 548379) to form a mapping population. The 'Fiskeby III' x 'Mandarin (Ottawa)' mapping population allows for a unique opportunity to understand multiple sources of abiotic stress resistance. This mapping population was utilized for IDC and canopy wilt tolerance QTL mapping at the University of Minnesota and is also being analyzed for other abiotic stress QTL by the USDA-ARS in North Carolina. From the University of Minnesota study, a major effect IDC QTL on chromosome 5, which explained 17% of the phenotypic variation was discovered. The major effect QTL on chromosome 5 is worthy of further investigation as a potential major source of IDC tolerance without yield drag (Mamidi et al, Buttenhoff et al). Two QTL for canopy wilt tolerance were found in the 'Fiskeby III' x 'Mandarin (Ottawa)' mapping study as well (Butenhoff 2015). The largest effect QTL co-localized with an IDC QTL found on chromosome 6, and accounted for 7.2% of the phenotypic variation.

Project Objectives:

The focus of my research is to fine map QTL for iron deficiency chlorosis and canopy wilt tolerance which originated from 'Fiskeby III.' Once discovered, I will assess the potential of these genes for use in northern breeding programs.

Preliminary Results:

In order to fine map the previously detected QTL, F_5 families from the original mapping population that were still heterozygous in the QTL region were advanced in order to drive recombination to create Heterogeneous Inbred Families (HIFs). When these HIFs were advanced for multiple generations, near isogenic lines (NILs), which are highly related and differ by only a region within the QTL, were generated. These lines were compared for tolerance to IDC and canopy wilt. As a result of these efforts, the chromosome 5 IDC QTL has been reduced in size by 66%. Populations are currently being developed in similar ways to fine map the chromosome 6 IDC QTL as well as the chromosome 6 canopy wilt QTL. Reducing the physical size of these QTL will make it easier for breeders to develop tolerant cultivars. By fine mapping these QTL it brings us one step closer to cloning causative genes and discovering the mechanisms behind abiotic stress tolerance. These QTL are also being introgressed into two University of Minnesota elite lines (MN 1612CN and MN1312CN) as well as the IDC susceptible variety Corsoy 79. By bringing these QTL into elite breeding material we hope to help farmers combat IDC and canopy wilt and improve their yields.

Works Cited

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