Comparison of Soybean Breeding and Variety Performance Between Conventional and Organic Production Systems in Ontario

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Introduction and Objectives

Organic production relies on cyclical manure-based fertility systems and mechanical tillage for weed control whereas conventional farmers have fertilizers and herbicides which allow them to modify the environment to suit crop demands. To increase organic productivity we may need to identify crop cultivars adapted to the unique challenges of their production systems.

Objective 1: Determine if current Ontario soybean cultivars perform differently in organic vs. conventional environments and examine what traits are responsible for these differences

Objective 2: Determine if selection of soybean lines for organic production systems needs to be performed on organically managed land in Ontario

Materials and Methods

Thirty-three food grade soybean lines in MG 0 were tested at Mapleton Organic farm in Moorefield, ON and at the University of Guelph's Elora Research Station in 2014 and 2015. In the conventional location herbicides were applied to control weeds in both years. In 2014 both potassium and phosphorus fertilizers were applied. Inter-row cultivation was used to control weeds in the organic location and manure was applied before planting in 2015 only.

Figure 1: Digital Images displaying canopy development of OAC 13-60C-ChCdn for stages V1(A), V3(B) and V5(C); Green leaf area was measured using color threshold tool and pixel counting tool in ImageJ to estimate LAI.

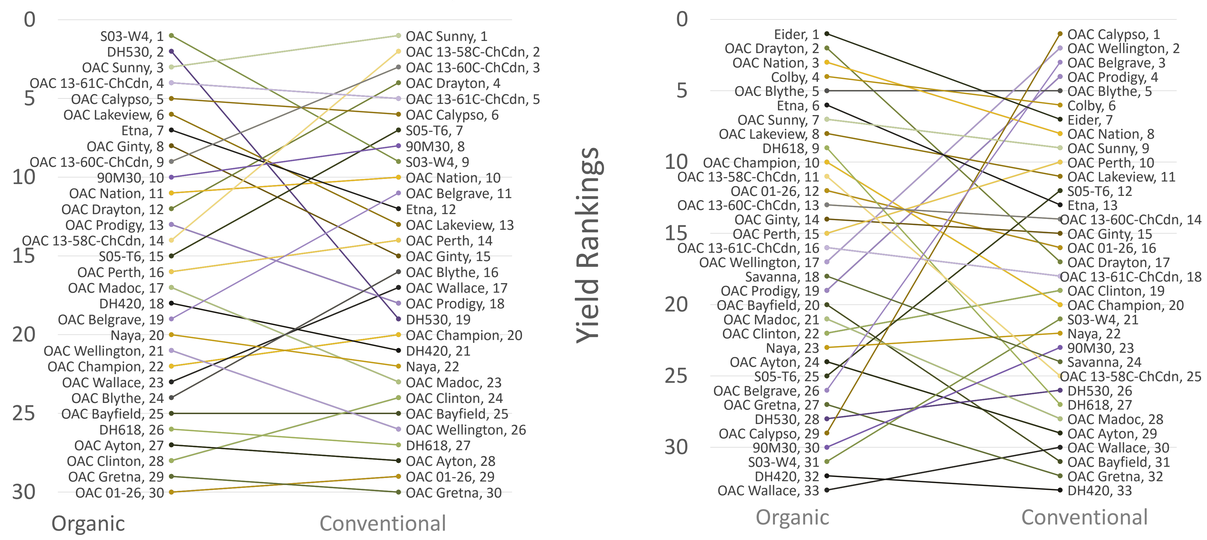
Cultivars and breeding lines were evaluated for standard agronomic traits such as yield, maturity, plant height, seed weight, protein and oil content, as well as traits theorized to be related to improved organic production, including: rate of canopy development, root length and nodule mass. ANOVA and Principal Components Analysis where used to compare the different traits in each environment and between environments.

Figure 2: Soil cores were taken using a root auger for each variety (A); soil cores were washed to separate out the roots and nodules (B); root samples were scanned and analysed using Winrhizo™ to measure root length

Two F5 Breeding populations (OAC Calypso x DH618 and OAC Sunny x S05-T6) composed of 152 and 160 RILs respectively, where planted in non-replicated single rows at both sites in 2014. 25% of RILs were selected in each population based on general agronomic appearance. The selected individuals from each production system were grown as unreplicated 4 row yield trials in 2015.

Results

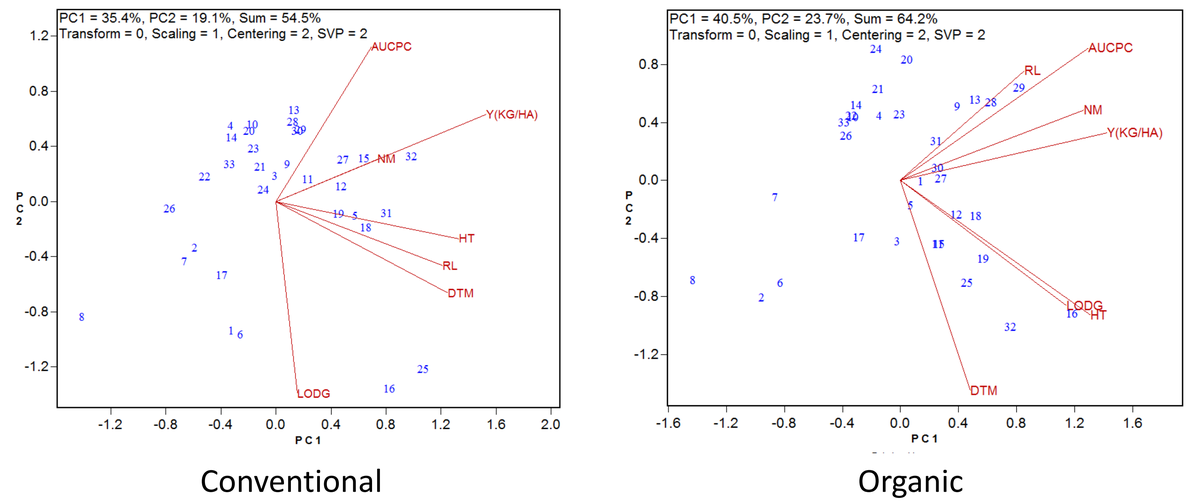
According to ANOVA there was a significant genotype X environment interaction across the organic and conventional locations in both 2014 and 2015. Across all the location years significant genotype X environment X year and year x genotype interaction were detected. In both years a significant difference between the varieties was detected in the organic location for total root length but not in the conventional location in either year.



2014: Tau-b Rank Correlation=0.57

2015: Tau-b Rank Correlation=0.31

Figure 3: Crossover diagrams of the yield ranking between the organic (Moorefield, ON) and conventional (Elora, ON) Locations with Tau-b Rank Correlation coefficient in 2014 and 2015



Conventional

Organic

Figure 4: Genotype x trait principal component biplots constructed using GGE Biplot™ for both the organic location (Moorefield, O by N) and the conventional location (Elora, ON) of yield (Y(KG/Ha)), plant height (HT), days to maturity (DTM), lodging (LODG), total root length (RL), nodule dry mass (NM) and rate of canopy development (AUCPC)

In 2014, 40 lines (selection pressure of 24.6%) were selected from the OAC Sunny x S05-T6 RIL population in each environment and 60% of the selections were the same between the organic and conventional locations. In the OAC Calypso x DH618, 38 lines (selection pressure of 25%) were selected and only 21% of the selections overlapped between the organic and conventional locations.

Conclusion

In conclusion, significant differences in cultivar performance are evident between the organic and conventional sites in both years although variety performance was inconsistent. The principal components analysis suggests that root length and rapid crop canopy development may be more closely related to yield in the organic environment whereas nodule mass was related to yield in both environments