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Determining Oat Yield and Quality Traits in Canada: Number of Locations and Replications

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Introduction

Oat varieties have to be evaluated based on data from multiple environments (years and sites) and for multiple traits. One research question is whether fewer locations can sufficiently identify the correct genotypes. An equally valid question is if fewer replicates or bulked samples are sufficient for determining certain traits. Proper answers to these questions can reduce test cost and improve breeding efficiency. Here we report the first year results of a study set up to answer these questions in relation to covered spring oats in Canada.

Materials and methods

30 oat breeding lines and check varieties were tested at 10 eastern Canada locations (4 in Ontario, 4 in Quebec, and 2 in Maritimes) and 3 western Canada locations (2 in Manitoba and 1 in Alberta). At each site a RCBD (randomized complete block design) was used and yield and grain quality traits were determined on the plot basis for all sites with some exceptions. Groat percentage, protein, oil, and beta-glucan content were determined based on NIR prediction.

Repeatability (or heritability) across replicates was calculated for each trait at each site. This statistic takes values from 0 to 1, with 1 meaning completely repeatable among replicates and 0 meaning completely un-repeatable among replicates. Across locations, the G/GGE ratio was calculated for each trait to determine the relative importance of genotype main effect (G) and genotype by environment interaction (GE). Bootstrap studies were conducted to investigate the effects of reducing the number of sites on the genotype ranks. All calculations were done with GGEbiplot software (Yan & Kang, 2003).

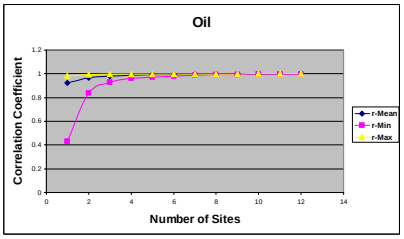

Figure 3. Mean, minimum, and maximum correlation coefficients between genotype means based on subsets & all sites for oil

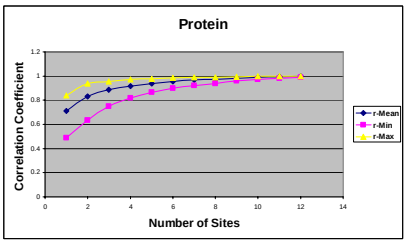

Figure 4. Mean, minimum, and maximum correlation coefficients between genotype means based on subsets & all sites for protein

Results and discussion

Repeatability across replicates

The repeatability across replicates was generally high for all measured traits (Table 1), being from 0.77 for protein to 0.92 for oil, averaged across locations. This value was even higher if some locations that had particularly low repeatability are excluded. For example, the repeatability for groat was particularly low at Portage MB (0.22), presumably due to inadequate cleaning of the seeds. This value was also low in Ottawa, ON (0.36) due to unknown reasons. Other locations had considerably higher repeatability for groat content. These results suggest that determining these traits based on bulked samples should be sufficiently reliable and determination on the plot basis may be unnecessary.

Repeatability across traits for each test site may be used to measure the data quality from each site. Table 1 indicates that Hebertville QC and Normandin QC had the highest data quality whereas Ottawa ON had the lowest data quality. Note that Hebertville QC and Normandin QC had 3 replicates whereas Ottawa ON had 4 replicates. Therefore the number of replicates does not seem critical for achieving better data quality.

Table 1. Repeatability of yield and quality traits and G/GGE ratio at each test site in 2007

Test sites	Rep	Yield	Groat	TW	TKW	Oil	Protein	ß-glucan	Mean
Bornholm, ON	4	0.95	0.94	0.54	0.88	0.96	0.86	0.91	**0.86**
Glenlea, MB	3	0.80	0.93	0.91		0.98	0.93	0.88	**0.91**
Hartland, NB	3	0.80	0.94	0.91		0.99	0.86	0.95	**0.91**
Hebertville, QC	3	0.93	0.96	0.96	0.98	0.98	0.91	0.97	**0.95**
Lacombe, AB	3	0.87	0.92	0.96	0.80	0.98	0.80	0.89	**0.89**
Nairn, ON	4	0.96	0.94	0.74	0.90	0.95	0.77	0.90	**0.88**
New Liskeard, ON	4	0.62	0.97	0.94	0.98	0.98	0.87	0.95	**0.90**
Normandin, QC	3	0.92	0.96	0.97	0.98	0.97	0.86	0.95	**0.94**
Ottawa, ON	4	0.80	0.36	0.96	0.67	0.89	0.62	0.70	**0.71**
Charlottetown, PEI	3	0.88		0.95	0.96				**0.93**
Portage, MB	3	0.84	0.22			0.93	0.31	0.34	**0.53**
Princeville, QC	3	0.89		0.88	0.95	0.87	0.66		**0.85**
AmQui, QC	3	0.83	0.84			0.98	0.84	0.85	**0.87**
Mean		**0.85**	**0.82**	**0.88**	**0.90**	**0.95**	**0.77**	**0.85**	
G/GGE		**0.42**	**0.92**	**0.60**	**0.71**	**0.82**	**0.53**	**0.75**	

Relative importance of G vs. GE

The G vs. GGE ratio (Table 1, bottom row) for groat was the highest (0.92), meaning that groat content was less affected by genotype by location interactions and fewer locations might be sufficient for its selection. On the other hand, grain yield had the lowest G vs. GGE ratio (0.42), meaning that more locations are needed for its accurate determination. Other traits had intermediate levels of G vs. GGE.

Number of sites required for genotype evaluation

Bootstrap of 1000 permutations indicates that at least 9 locations are needed to achieve a guaranteed minimum correlation of 0.8 for yield (Fig. 1), relative to the genotype ranking based on all 13 locations. However, only 2 locations are needed to achieve this level of reliability for groat and oil (Fig. 2 and 3). Four locations would be needed for the same criterion for protein (Fig.4).

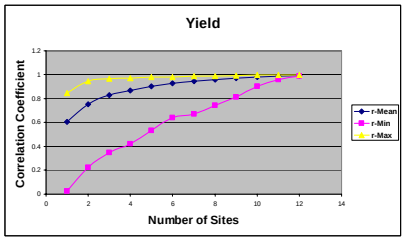

Figure 1. Mean, minimum, and maximum correlation coefficients between genotype means based on subsets & all sites for grain yield

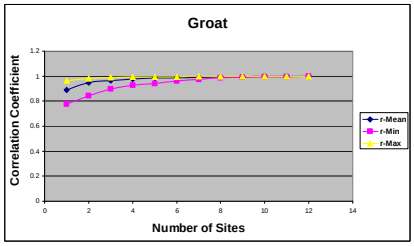

Figure 2. Mean, minimum, and maximum correlation coefficients between genotype means based on subsets & all sites for groat

Conclusions

1. Repeatability across replicates were generally high for all traits at most locations, indicating that replicates may be reduced from 4 to 3 and bulk samples may be sufficient for accurate determination of most traits.

2. Yield has the most genotype by environment interaction relative to the genotype main effects and all 13 locations seem to be necessary for reliable selection of yield. However, groat and oil were highly stable across environments and two locations may be sufficient for reliable selection.

References

Yan, W. and M.S. Kang. 2003. GGE Biplot Analysis: A graphical Tool for Breeders, Geneticists and Agronomists. CRC Press. Boca Raton, FL.

"Important note regarding results presented in scientific posters: The research reported here is in progress, and therefore the study results have not been subjected to scientific peer review."

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