**Supplemental Tables S2, S4, S5, S6, S7, S8, and S9.**

(Supplemental Tables S1 and S3 are separate .csv files)

**Table S2.** Structures that could be implemented for testing based on known experimental design for 2014-2016 G2F data. In 2016 there were no incomplete blocks in the design.

|  |  |  |
| --- | --- | --- |
| Model | Structures Accounted For | Years Tested |
|  | Fixed Genetic Effect | 2014-2016 |
|  | Linear covariate for stand count | 2014-2016 |
|  | Quadratic covariate for stand count | 2014-2016 |
|  | Replication effect | 2014-2016 |
|  | Nested effect of blocks within reps | 2014-2015 |

**Table S4**. Ten clusters of hybrids defined by Ward’s method applied to genotype information. Cluster assignments of individual hybrids are presented in File S10.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Cluster |  | Representative hybrids |  | N |
| 1 |  | Stiff Stalk (SS) × Non-Stiff Stalk (NSS), SS × tropical, and SS × mixed background hybrids |  | 427 |
| 2 |  | Recombinant inbred lines (RILs) from the maize nested association mapping family B73 × Ki13 (Z013) crossed to various testers |  | 120 |
| 3 |  | Diverse SS × NSS hybrids and crosses from B73 × Mo17 (IBM) RILs to various testers |  | 339 |
| 4 |  | Hybrids created with tester inbred 3IIH6 |  | 108 |
| 5 |  | ex-PVP combinations and Mixed x LH195, LH198, and PB80 testers |  | 338 |
| 6 |  | Hybrids created with tester inbred LH82 |  | 97 |
| 7 |  | Hybrids created with tester inbred PHZ51 |  | 142 |
| 8 |  | PHB47 (SS) × Mixed pedigree hybrids |  | 123 |
| 9 |  | CG102 hybrids from the Guelph, Canada breeding program |  | 97 |
| 10 |  | Hybrids created with tester inbred LH185 |  | 127 |

**Table S5.**  Pairwise correlations and within-environment variances from Echidna models fit on yield.

|  |  |  |
| --- | --- | --- |
| Model | Pairwise Correlation  Mean (Min – Max) | Within-Site Genotypic Variance Mean (Min – Max) |
| Independent hybrid effects (IDVG) | | | |
|  | 0.481 | 1.829 |
|  | 0.497 (0.036 - 0.955) | 1.815 (0.076 - 7.356) |
|  | 0.423 (-0.474 – 0.966) | 1.789 (0.070 – 7.174) |
|  | 0.439 (-0.544 – 0.937) | 1.814 (0.071 – 7.448) |
| Additive () genomic relationships + independent hybrid effects () | | | |
|  | 0.469 | 2.274 |
|  | 0.673 (0.024 – 0.950) | 4.619 (0.305 – 16.161) |
|  | 0.403 (-0.229 – 0.861) | 2.450 (0.320 – 19.728) |
|  | 0.422 (-0.184 – 0.884) | 2.253 (0.089 – 11.281) |
|  | 0.637 (-0.339 – 0.965) | 4.556 (0.333 – 15.818) |
|  | 0.355 (-0.576 – 0.888) | 2.470 (0.296 – 20.103) |
|  | 0.400 (-0.540 – 0.928) | 2.255 (0.106 – 11.018) |
| Dominance () genomic relationships + independent hybrid effects () | | | |
|  | 0.388 | 1.1011 |
|  | 0.432 (0.042 – 0.860) | 1.734 (0.168 – 8.897) |
|  | 0.355 (-0.011 – 0.857) | 1.611 (0.139 – 9.398) |
|  | 0.370 (0.007 – 0.857) | 1.552 (0.106 – 8.674) |
|  | 0.410 (-0.411 – 0.928) | 1.697 (0.161 – 8.780) |
|  | 0.323 (-0.471 – 0.862) | 1.612 (0.156 – 9.319) |
|  | 0.354 (-0.486 – 0.916) | 1.528 (0.105 – 8.533) |
| Additive () genomic relationships + dominance () genomic relationships + independent hybrid effects () | | | |
|  | 0.433 | 1.998 |
|  | 0.462 (0.160 – 0.548) | 2.022 (1.705 – 5.832) |
|  | 0.398 (0.075 – 0.792) | 1.951 (0.980 – 10.287) |

**Table S6.** ANOVA model for Yield to using weather-based environment clusters demonstrate relationship between environmental data and environment main effect and G×E variances.

|  |  |  |
| --- | --- | --- |
| Component | Variance | Std. Err |
|  | 0.842 | 0.0382 |
|  | 3.405 | 0.6339 |
|  | 0.117 | 0.0172 |
|  | 0.865 | 0.0221 |
|  | 1 |  |

**Table S7.** Model fit information for stepwise regression models using 5, 10, 15, and 30-day windowed environmental covariates as a predictor of parameter estimates from respective and models. Best fitting model for each parameter by BIC are in bold.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Term | Model | Sliding Window Set | DF | Residual DF | BIC |  |  |
| Env Mean Yield | -- | Thirty Day | 3 | 62 | 73.369 | 0.302 | 0.280 |
| Fifteen Day | 3 | 62 | 73.091 | 0.305 | 0.283 |
| Ten Day | 9 | 56 | 56.448 | 0.634 | 0.582 |
| Five Day | 16 | 49 | **13.941** | **0.879** | **0.841** |
|  |  | Thirty Day | 3 | 62 | -92.202 | 0.271 | 0.247 |
| Fifteen Day | 5 | 60 | -92.645 | 0.363 | 0.321 |
| Ten Day | 5 | 60 | -94.337 | 0.379 | 0.338 |
| Five Day | 16 | 49 | -108.238 | 0.753 | 0.677 |
|  | Thirty Day | 6 | 59 | -150.857 | 0.430 | 0.382 |
| Fifteen Day | 3 | 62 | -146.137 | 0.257 | 0.233 |
| Ten Day | 3 | 62 | -148.959 | 0.288 | 0.265 |
| Five Day | 16 | 49 | **-177.682** | **0.801** | **0.741** |
|  |  | Thirty Day | 2 | 63 | 92.970 | 0.161 | 0.147 |
| Fifteen Day | 2 | 63 | 100.006 | 0.065 | 0.050 |
| Ten Day | 2 | 63 | 99.201 | 0.076 | 0.061 |
| Five Day | 13 | 52 | **68.799** | **0.714** | **0.649** |
|  | Thirty Day | 2 | 63 | 1.314 | 0.138 | 0.124 |
| Fifteen Day | 1 | 64 | 6.802 | 0 | 0 |
| Ten Day | 1 | 64 | 6.802 | 0 | 0 |
| Five Day | 4 | 61 | 1.766 | 0.237 | 0.199 |

**Table S8.** Loadings terms for the model with best BIC from stepwise regressionanalysis.

|  |  |  |  |
| --- | --- | --- | --- |
| Model Response | Term | Estimate | Std. Error |
| Env Mean Yields | Intercept | 9.16214 | 0.09514 |
| Mean Temp (Days 66-70) | -2.07662 | 0.27307 |
| Mean High Temp (Days 36-40) | -0.95384 | 0.11073 |
| Mean Humid (Days 21-25) | -0.01674 | 0.13395 |
| Mean Humid (Days 91-95) | 0.61907 | 0.12857 |
| Rain Accumulation (Days 106-110) | -0.30856 | 0.10819 |
| Mean Photo (Days 71-75) | 0.56959 | 0.12552 |
| Sand | 0.60056 | 0.12386 |
| Rain Accumulation (Days 6-10) | 0.76056 | 0.11553 |
| Mean High Temp (Days 26-30) | 0.53926 | 0.11975 |
| Mean Wind (Days 21-25) | 0.77772 | 0.13195 |
| Mean Wind (Days 31-35) | -0.64829 | 0.12655 |
| Mean Humid (Days 6-10) | -0.48878 | 0.13069 |
| Mean Low Temp (Days 66-70) | 0.9927 | 0.2648 |
| Percent Days With Rain (Days 76-80) | -0.42209 | 0.11658 |
| Percent Days With Rain (Days 101-105) | 0.36562 | 0.10615 |
|  | Intercept | 0.733 | 0.02179 |
| Mean Humid (Days 126-130) | 0.12997 | 0.02942 |
| GDD (Days 96-100) | -0.09306 | 0.02767 |
| Percent Days With Rain (Days 21-25) | -0.16397 | 0.0301 |
| Mean Humid (Days 61-70) | 0.10761 | 0.02819 |
| Rain Accumulation (Days 6-10) | 0.15628 | 0.02623 |
| Rain Accumulation (Days 66-70) | -0.03406 | 0.02613 |
| Mean Peak GHI (Days 126-130) | -0.0986 | 0.03499 |
| Percent Days With Rain (Days 76-80) | -0.12001 | 0.0285 |
| GDD (Days 71-75) | 0.13328 | 0.03276 |
| Mean Peak GHI (Days 76-80) | -0.23883 | 0.03903 |
| Mean Peak GHI Days(96-100) | 0.17515 | 0.03662 |
| Mean High Temp (Days 66-70) | -0.13308 | 0.03017 |
| Mean Humid (Days 76-80) | -0.13335 | 0.03689 |
| Mean Wind (Days 121-125) | -0.06828 | 0.02405 |
| GDD (Days 26-30) | 0.06665 | 0.02852 |

**Table S9.** Prediction ability for hybrid marginal values across environments from different models using 10-fold cross-validation. Within each fold, 10% of hybrids were held out from the training set; their mean yield across environments was predicted, and the correlation between predicted and observed was estimated. Training set phenotypes were hybrid BLUEs at each environment, or in the case of two-step models, overall BLUEs across environments. Inverses of variances of BLUEs were as weights for all analyses.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Model |  | Genomic relationship matrices |  | Mean prediction ability |  | Standard deviation of prediction ability |
| Two-step |  | A |  | 0.59 |  | 0.03 |
| Two-step |  | D |  | 0.66 |  | 0.03 |
| Two-step |  | A+D |  | 0.68 |  | 0.02 |
| Cross-classified hybrids and environments |  | A |  | 0.54 |  | 0.04 |
| Cross-classified hybrids and environments |  | D |  | 0.64 |  | 0.03 |
| Cross-classified hybrids and environments |  | A+D |  | 0.64 |  | 0.03 |
| FA1 environments |  | A |  | 0.54 |  | 0.04 |
| FA1 environments |  | D |  | 0.62 |  | 0.03 |