**Supplementary Table 1.** Average grain yield and grain protein content for the nested association mapping population of spring wheat planted for three years (2014-16) in the US Pacific Northwest.

|  |  |  |
| --- | --- | --- |
| Environment | Grain yield (t/ha) | GPC (%) |
| 2014 | 1.9 | 14.4 |
| 2015 | 1.7 | 12.2 |
| 2016 | 2.4 | 12.6 |

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| **Supplementary Table 2.** Phenotypic correlation between grain yield and eight spectral reflectance indices derived in this study at the heading stage of spring wheat population planted for three environments (2014-16) in the US Pacific Northwest. |
| Yield | NDVI a | NWI b | WI c | SR d | GNDVI e | PRI f | NCPI g | ARI h |
| 2014 | 0.20\*\*\* | 0.19\*\*\* | 0.19\*\*\* | 0.15\*\*\* | 0.26\*\*\* | 0.21\*\*\* | -0.13\* | -0.16\*\*\* |
| 2015 | 0.03 | 0.00 | 0.00 | 0.01 | 0.05 | 0.07 | -0.07 | -0.09\* |
| 2016 | 0.15\*\*\* | 0.05 | 0.05 | 0.16\*\*\* | 0.20\*\*\* | 0.16\*\*\* | -0.15\*\*\* | -0.23\*\*\* |
| a NDVI, Normalized difference vegetation index; b NWI, Normalized water index; c WI, Water index; d SR, Simple ratio; e GNDVI, Green normalized difference vegetation index; f PRI, Photochemical reflectance index; g NCPI, Normalized chlorophyll pigment ratio index; h ARI, Anthocyanin reflectance index; \*\*\* significant at P < 0.0001; \*\* significant at P < 0.001; \* significant at P < 0.05 |

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| **Supplementary Table 3.** Phenotypic correlation between grain protein content and eight spectral reflectance indices derived in this study at the grain filling stage of spring wheat population planted for three environments (2014-16) in the US Pacific Northwest. |
| GPC | NDVI a | NWI b | WI c | SR d | GNDVI e | PRI f | NCPI g | ARI h |
| 2014 | 0.26\*\*\* | 0.27\*\*\* | 0.27\*\*\* | 0.28\*\*\* | 0.29\*\*\* | 0.10 | -0.20\*\*\* | -0.12\* |
| 2015 | .08\* | -0.03 | -0.02 | 0.11\* | 0.18\*\*\* | 0.01 | 0.02 | 0.27\*\*\* |
| 2016 | -0.19\*\*\* | -0.22\*\*\* | -0.22\*\*\* | -0.13\*\*\* | -0.15\*\*\* | -0.10\* | 0.13\* | 0.12\* |
| a NDVI, Normalized difference vegetation index; b NWI, Normalized water index; c WI, Water index; d SR, Simple ratio; e GNDVI, Green normalized difference vegetation index; f PRI, Photochemical reflectance index; g NCPI, Normalized chlorophyll pigment ratio index; h ARI, Anthocyanin reflectance index; \*\*\* significant at P < 0.0001; \*\* significant at P < 0.001; \* significant at P < 0.05 |

**Supplementary Table 4.** Genetic correlation of spectral reflectance indices with grain yield and grain protein content across three years.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Trait | NDVI a | NWI b | WI c | SR d | GNDVI e | PRI f | NCPI g | ARI h |
| Grain yield | 0.73 | 0.65 | 0.59 | 0.68 | 0.65 | 0.52 | 0.56 | 0.59 |
| GPC | 0.61 | 0.65 | 0.69 | 0.72 | 0.70 | 0.48 | 0.53 | 0.55 |
| a NDVI, Normalized difference vegetation index; b NWI, Normalized water index; c WI, Water index; d SR, Simple ratio; e GNDVI, Green normalized difference vegetation index; f PRI, Photochemical reflectance index; g NCPI, Normalized chlorophyll pigment ratio index; h ARI, Anthocyanin reflectance index; all genetic correlations are significant at p < 0.05 |

**Supplementary Table 5.** Phenotypic correlation of grain protein content and grain yield across the environments.

|  |  |  |
| --- | --- | --- |
| Environments | Grain yield | Grain protein content |
| 2014-15 | 0.47 | 0.49 |
| 2014-16 | 0.42 | 0.42 |
| 2015-16 | 0.55 | 0.59 |
| All correlations were significant at p < 0.05 |