# Supplementary Table

Supplementary Table S1: Descriptive data including mean, average coefficients of variation (AVC%) and range for 19 above ground traits in three environments (E1, E2, and E3) along with their average value.

| Traits | Environment | Mean | ACV% | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| Heading time (days) | E1 | 184.69 | 16.97 | 53.80 | 242.33 | 188.53 |
| HT | E2 | 166.72 | 36.00 | 59.75 | 284.00 | 224.25 |
| | E3 | 108.71 | 5.36 | 82.00 | 128.00 | 46.00 |
| | **Average** | **164.66** | **21.21** | **64.00** | **262.33** | **198.33** |
| Flowering time (days) | E1 | 190.85 | 15.65 | 57.40 | 245.00 | 187.60 |
| FT | E2 | 171.56 | 35.22 | 63.75 | 289.00 | 225.25 |
| | E3 | 114.62 | 4.26 | 88.67 | 132.00 | 43.33 |
| | **Average** | **170.39** | **20.08** | **68.00** | **268.00** | **200.00** |
| Maturity time (days) | E1 | 246.06 | 7.28 | 140.00 | 275.00 | 135.00 |
| MT | E2 | 269.20 | 18.97 | 110.50 | 322.00 | 211.50 |
| | E3 | 143.11 | 2.63 | 130.00 | 155.00 | 25.00 |
| | **Average** | **231.09** | **11.62** | **143.58** | **300.67** | **157.09** |
| Plant height (cm) | E1 | 128.51 | 18.41 | 47.00 | 186.00 | 139.00 |
| PH | E2 | 119.81 | 19.38 | 63.00 | 178.00 | 115.00 |
| | E3 | 119.95 | 10.87 | 82.00 | 148.00 | 66.00 |
| | **Average** | **123.48** | **14.00** | **65.00** | **159.67** | **94.67** |
| Total tiller number | E1 | 5.92 | 29.49 | 2.33 | 14.00 | 11.67 |
| TTN | E2 | 8.22 | 32.61 | 3.00 | 20.00 | 17.00 |
| | E3 | 6.75 | 17.26 | 4.00 | 11.00 | 7.00 |
| | **Average** | **6.62** | **22.47** | **3.50** | **12.29** | **8.79** |
| Effective tiller number | E1 | 3.40 | 34.90 | 1.25 | 8.00 | 6.75 |
| ETN | E2 | 4.69 | 41.04 | 1.00 | 14.00 | 13.00 |
| | E3 | 4.62 | 24.26 | 3.00 | 9.00 | 6.00 |
| | **Average** | **3.94** | **26.76** | **1.33** | **8.25** | **6.92** |

| | | | | | | |
|---|---|---|---|---|---|---|
| Spike length (cm) | E1 | 6.59 | 15.88 | 4.00 | 9.50 | 5.50 |
| SpL | E2 | 7.50 | 17.44 | 4.50 | 11.75 | 7.25 |
| | E3 | 9.64 | 11.11 | 6.00 | 12.50 | 6.50 |
| | **Average** | **7.40** | **14.17** | **4.00** | **9.72** | **5.72** |
| Peduncle length (cm) | E1 | 43.41 | 28.59 | 11.00 | 76.50 | 65.50 |
| PL | E2 | 52.28 | 23.16 | 23.00 | 81.50 | 58.50 |
| | E3 | 60.49 | 16.31 | 35.00 | 81.00 | 46.00 |
| | **Average** | **48.69** | **21.29** | **11.00** | **70.38** | **59.38** |
| First leaf area ($cm^2$) | E1 | 24.17 | 44.75 | 2.36 | 58.16 | 55.80 |
| FLA | E2 | 29.62 | 46.17 | 4.35 | 76.73 | 72.38 |
| | E3 | 20.41 | 26.99 | 6.75 | 37.48 | 30.73 |
| | **Average** | **24.42** | **34.56** | **4.20** | **47.84** | **43.64** |
| Second leaf area ($cm^2$) | E1 | 32.60 | 34.73 | 4.37 | 63.21 | 58.84 |
| SLA | E2 | 34.80 | 37.16 | 5.97 | 84.27 | 78.30 |
| | E3 | 25.09 | 19.90 | 13.35 | 41.63 | 28.28 |
| | **Average** | **31.12** | **27.36** | **6.83** | **57.72** | **50.89** |
| Shoot angle ($^O$) | E1 | 51.19 | 35.16 | 5.00 | 86.37 | 81.37 |
| Sang | E2 | 57.60 | 25.59 | 8.88 | 86.53 | 77.65 |
| | E3 | 62.18 | 18.85 | 20.00 | 90.00 | 70.00 |
| | **Average** | **54.34** | **26.73** | **6.11** | **81.14** | **75.03** |
| Biomass/plant (g) | E1 | 9.03 | 36.13 | 2.52 | 25.52 | 23.00 |
| BPP | E2 | 14.11 | 49.71 | 1.86 | 55.46 | 53.60 |
| | E3 | 6.41 | 26.32 | 1.85 | 11.59 | 9.74 |
| | **Average** | **9.71** | **34.56** | **2.85** | **34.13** | **31.28** |
| Yield/plant (g) | E1 | 1.05 | 44.52 | 0.11 | 2.47 | 2.36 |
| YPP | E2 | 1.58 | 48.62 | 0.06 | 4.34 | 4.28 |
| | E3 | 0.66 | 79.62 | 0.11 | 4.30 | 4.19 |
| | **Average** | **1.10** | **38.19** | **0.11** | **3.05** | **2.94** |
| Thousand kernel weight (g) | E1 | 26.59 | 22.76 | 6.63 | 43.18 | 36.55 |
| TKW | E2 | 30.81 | 25.58 | 8.15 | 46.90 | 38.75 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | E3 | 24.44 | 20.25 | 9.80 | 47.60 | 37.80 |
| | **Average** | **27.18** | **17.94** | **7.24** | **39.58** | **32.34** |
| Seed length (mm) | E1 | 8.84 | 6.77 | 6.24 | 10.50 | 4.26 |
| SL | E2 | 9.04 | 7.81 | 5.50 | 10.77 | 5.27 |
| | E3 | 8.57 | 6.34 | 6.07 | 9.63 | 3.56 |
| | **Average** | **8.83** | **5.86** | **6.08** | **10.08** | **4.00** |
| Seed width (mm) | E1 | 2.54 | 9.58 | 1.67 | 3.32 | 1.65 |
| SW | E2 | 2.64 | 10.29 | 1.69 | 3.47 | 1.78 |
| | E3 | 2.44 | 8.58 | 1.69 | 3.50 | 1.81 |
| | **Average** | **2.54** | **8.18** | **1.68** | **3.39** | **1.71** |
| Seed thickness (mm) | E1 | 2.39 | 11.70 | 1.31 | 3.14 | 1.83 |
| ST | E2 | 2.37 | 12.00 | 1.31 | 3.08 | 1.77 |
| | E3 | 2.16 | 9.71 | 1.55 | 3.21 | 1.66 |
| | **Average** | **2.33** | **8.75** | **1.41** | **3.08** | **1.67** |
| Seed area ($mm^2$) | E1 | 14.85 | 13.23 | 8.50 | 20.53 | 12.03 |
| SA | E2 | 15.81 | 13.64 | 9.00 | 20.20 | 11.20 |
| | E3 | 14.13 | 12.19 | 8.10 | 18.20 | 10.10 |
| | **Average** | **14.92** | **10.85** | **8.79** | **18.78** | **9.99** |
| Threshability | E1 | 2.88 | 19.59 | 1.00 | 4.00 | 3.00 |
| T | E2 | 3.35 | 17.03 | 1.00 | 4.00 | 3.00 |
| | E3 | 3.01 | 14.78 | 1.00 | 4.00 | 3.00 |
| | **Average** | **3.02** | **17.10** | **1.00** | **4.00** | **3.00** |

Supplementary Table S2: Analysis of variance (ANOVA) table for above ground traits in three environments of 263 wild emmer accessions.

| | | **Sources of variation** | | | |
|---|---|---|---|---|---|
| | | **Genotype (G)** | **Environment (E)** | **G X E** | **Error** |
| | **Degrees of freedom** | **262** | **2** | **434** | **1405** |

| | | | | | |
|---|---|---|---|---|---|
| **Mean of square** | **HT** | 6098.01*** | 689326.09*** | 2449.07*** | 26.28 |
| | **FT** | 5827.51*** | 692428.12*** | 2520.67*** | 18.87 |
| | **MT** | 3200.17*** | 1792208.68*** | 2223.76*** | 54.74 |
| | **PH** | 1807.81*** | 24483.21*** | 738.69*** | 70.08 |
| | **TTN** | 12.06*** | 717.03*** | 6.78*** | 1.82 |
| | **ETN** | 5.66*** | 316.87*** | 4.23*** | 0.71 |
| | **SpL** | 5.04*** | 1151.06*** | 2.20*** | 0.59 |
| | **PL** | 484.58*** | 33431.93*** | 262.11*** | 43.76 |
| | **FLA** | 410.75*** | 10492.76*** | 211.03*** | 32.31 |
| | **SLA** | 416.36*** | 13773.13*** | 191.66*** | 27.66 |
| | **SAng** | 995.59*** | 10587.39*** | 333.04*** | 42.99 |
| | **BPP** | 54.63*** | 6382.37*** | 35.70*** | 1.11 |
| | **YPP** | 1.06*** | 91.49*** | 0.81*** | 0.03 |
| | **TKW** | 138.65*** | 5333.06*** | 79.57*** | 8.27 |
| | **SL** | 2.06*** | 27.80*** | 0.45*** | 0.30 |
| | **SW** | 0.28*** | 4.72*** | 0.08*** | 0.05 |
| | **ST** | 0.25*** | 9.55*** | 0.12*** | 0.06 |
| | **SA** | 15.97*** | 372.19*** | 5.84*** | 1.33 |
| | **T** | 1.65*** | 32.30*** | 0.22*** | 0.15 |

*** $p < 0.001$

Supplementary Table S3: Pearson's correlation between different shoot traits in E1.

| | FT | MT | PH | TTN | ETN | SpL | PL | FLA | SLa | SAng | BPP | YPP | TKW | SL | SW | ST | SA | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **HT** | 0.99** | 0.81** | -0.03 | 0.03 | -0.04 | -0.31** | -0.31** | -0.55** | -0.40** | -0.30** | 0.01 | -0.28** | -0.43** | -0.26** | -0.43** | -0.34** | -0.37** | 0.15* |
| **FT** | | 0.81** | -0.02 | 0.04 | -0.06 | -0.31** | -0.29** | -0.53** | -0.39** | -.306** | -0.03 | -0.30** | -0.44** | -0.25** | -0.43** | -0.34** | -0.36** | 0.16** |
| **MT** | | | -0.11 | 0.08 | -0.05 | -0.28** | -0.31** | -0.44** | -0.37** | -0.22** | -0.03 | -0.31** | -0.41** | -0.26** | -0.39** | -0.33** | -0.36** | 0.14* |
| **PH** | | | | 0.03 | -0.09 | 0.48** | 0.72** | 0.35** | 0.58** | 0.23** | 0.51** | 0.34** | 0.24** | 0.29** | 0.23** | 0.19** | 0.35** | 0.13* |
| **TTN** | | | | | 0.70** | -0.03 | 0.13* | -0.11 | -0.12 | 0.21** | 0.50** | 0.35** | -0.03 | -0.07 | -0.14* | -0.03 | -0.13* | 0.09 |
| **ETN** | | | | | | -0.13* | 0.13* | -0.23** | -0.28** | 0.17** | 0.46** | 0.39** | -0.05 | -0.18** | -0.19** | -0.11 | -0.24** | 0.02 |
| **SpL** | | | | | | | 0.40** | 0.54** | 0.66** | 0.07 | 0.37** | 0.36** | 0.35** | 0.35** | 0.28** | 0.15* | 0.37** | 0.07 |
| **PL** | | | | | | | | 0.41** | 0.46** | 0.28** | 0.47** | 0.43** | 0.22** | 0.26** | 0.18** | 0.1 | 0.26** | 0.15* |
| **FLA** | | | | | | | | | 0.79** | 0.24** | 0.13* | 0.30** | 0.46** | 0.44** | 0.46** | 0.36** | 0.54** | -0.07 |
| **SLA** | | | | | | | | | | 0.22** | 0.26** | 0.35** | 0.46** | 0.49** | 0.43** | 0.35** | 0.57** | 0.03 |
| **SAng** | | | | | | | | | | | 0.25** | 0.26** | 0.1 | 0.01 | 0.14* | 0.20** | 0.09 | 0.02 |
| **BPP** | | | | | | | | | | | | 0.68** | 0.16** | 0.03 | 0.07 | 0.04 | 0.08 | 0.05 |
| **YPP** | | | | | | | | | | | | | 0.46** | 0.06 | 0.32** | 0.24** | 0.25** | -0.15* |
| **TKW** | | | | | | | | | | | | | | 0.51** | 0.83** | 0.54** | 0.83** | -0.30** |
| **SL** | | | | | | | | | | | | | | | 0.32** | 0.18** | 0.75** | 0.11 |
| **SW** | | | | | | | | | | | | | | | | 0.63** | 0.83** | -0.40** |
| **ST** | | | | | | | | | | | | | | | | | 0.50** | -0.25** |
| **SA** | | | | | | | | | | | | | | | | | | -0.22** |

** Correlation is significant at 0.01 level; * Correlation is significant at 0.05 level.

Supplementary Table S3 (Contd.): Pearson's correlation between different shoot traits in E2.

| | FT | MT | PH | TTN | ETN | SpL | PL | FLA | SLa | SAng | BPP | YPP | TKW | SL | SW | ST | SA | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **HT** | 0.99 ** | 0.72 ** | 0.25 ** | 0.20 ** | 0.15 * | -0.19 ** | -0.04 | -0.26 ** | -0.29 ** | -0.06 | 0.42 ** | -0.01 | -0.05 | 0.15 * | -0.21 ** | -0.20 ** | -0.1 | 0.28 ** |
| **FT** | | 0.72 ** | 0.25 ** | 0.20 ** | 0.14 * | -0.18 ** | -0.05 | -0.26 ** | -0.29 ** | -0.05 | 0.41 ** | -0.01 | -0.06 | 0.14 * | -0.21 ** | -0.20 ** | -0.1 | 0.28 ** |
| **MT** | | | 0.39 ** | 0.14 * | 0.02 | -0.06 | 0.06 | 0.01 | -0.05 | 0.04 | 0.47 ** | 0.17 * | 0.14 * | 0.28 ** | 0.01 | -0.01 | 0.08 | 0.42 ** |
| **PH** | | | | -0.09 | -0.01 | 0.38 ** | 0.63 ** | 0.20 ** | 0.38 ** | 0.11 | 0.40 ** | 0.32 ** | 0.42 ** | 0.31 ** | 0.29 ** | 0.25 ** | 0.38 ** | 0.18 ** |
| **TTN** | | | | | 0.81 ** | -0.04 | -0.11 | -0.18 ** | -0.27 ** | 0.01 | 0.38 ** | 0.31 ** | -0.1 | -0.04 | -0.05 | -0.03 | -0.11 | -0.03 |
| **ETN** | | | | | | -0.04 | 0.04 | -0.21 ** | -0.22 ** | -0.03 | 0.33 ** | 0.38 ** | 0.01 | -0.05 | -0.07 | -0.01 | -0.09 | -0.02 |
| **SpL** | | | | | | | 0.44 ** | 0.58 ** | 0.68 ** | 0.15 * | 0.12 | 0.20 ** | 0.22 ** | 0.19 ** | 0.29 ** | 0.22 ** | 0.35 ** | 0.13 |
| **PL** | | | | | | | | 0.32 ** | 0.39 ** | 0.18 ** | 0.12 | 0.20 ** | 0.21 ** | 0.22 ** | 0.18 ** | 0.15 * | 0.25 ** | 0.13 |
| **FLA** | | | | | | | | | 0.84 ** | 0.11 | -0.04 | 0.16 * | 0.32 ** | 0.35 ** | 0.43 ** | 0.37 ** | 0.50 ** | 0.08 |
| **SLA** | | | | | | | | | | 0.15 * | 0.01 | 0.25 ** | 0.41 ** | 0.32 ** | 0.44 ** | 0.38 ** | 0.53 ** | 0.1 |
| **SAng** | | | | | | | | | | | -0.06 | -0.01 | 0.07 | -0.08 | 0.14 * | 0.03 | 0.1 | -0.11 |
| **BPP** | | | | | | | | | | | | 0.46 ** | 0.08 | 0.20 ** | 0.04 | 0.02 | 0.12 | 0.30 ** |
| **YPP** | | | | | | | | | | | | | 0.50 ** | 0.23 ** | 0.33 ** | 0.34 ** | 0.32 ** | 0.08 |
| **TKW** | | | | | | | | | | | | | | 0.52 ** | 0.77 ** | 0.68 ** | 0.82 ** | -0.01 |
| **SL** | | | | | | | | | | | | | | | 0.37 ** | 0.25 ** | 0.74 ** | 0.46 ** |
| **SW** | | | | | | | | | | | | | | | | 0.80 ** | 0.81 ** | -0.18 ** |
| **ST** | | | | | | | | | | | | | | | | | 0.64 ** | -0.14 * |
| **SA** | | | | | | | | | | | | | | | | | | 0.13 |

** Correlation is significant at 0.01 level; * Correlation is significant at 0.05 level.

Supplementary Table S3 (Cond.): Pearson's correlation between different shoot traits in E3.

| | FT | MT | PH | TTN | ETN | SpL | PL | FLA | SLa | SAng | BPP | YPP | TKW | SL | SW | ST | SA | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **HT** | 0.80 ** | 0.59 ** | -0.36 ** | 0.14 * | 0.09 | -0.36 ** | -0.48 ** | -0.28 ** | 0.04 | -0.11 | -0.32 ** | -0.28 ** | -0.51 ** | -0.31 ** | -0.54 ** | -0.43 ** | -0.55 ** | 0.23 ** |
| **FT** | | 0.56 ** | -0.19 ** | 0.11 | 0.12 | -0.36 ** | -0.32 ** | -0.33 ** | 0.04 | -0.04 | -0.23 ** | -0.28 ** | -0.35 ** | -0.11 | -0.42 ** | -0.31 ** | -0.35 ** | 0.17 * |
| **MT** | | | -0.09 | 0.04 | -0.01 | -0.14 * | -0.24 ** | -0.18 ** | 0.08 | -0.03 | -0.08 | -0.12 | -0.35 ** | -0.32 ** | -0.33 ** | -0.24 ** | -0.40 ** | 0.06 |
| **PH** | | | | -0.26 ** | -0.22 ** | 0.48 ** | 0.86 ** | 0.26 ** | 0.25 ** | 0.16 * | 0.50 ** | 0.03 | 0.34 ** | 0.40 ** | 0.39 ** | 0.31 ** | 0.49 ** | -0.1 |
| **TTN** | | | | | 0.73 ** | -0.19 ** | -0.26 ** | -0.11 | -0.15 * | -0.18 ** | -0.13 | -0.07 | -0.20 ** | -0.15 * | -0.17 * | -0.13 | -0.19 ** | 0.07 |
| **ETN** | | | | | | -0.13 * | -0.23 ** | -0.11 | -0.08 | -0.16 * | 0.03 | 0.06 | -0.06 | -0.07 | -0.06 | -0.06 | -0.09 | 0.01 |
| **SpL** | | | | | | | 0.46 ** | 0.50 ** | 0.28 ** | 0.02 | 0.49 ** | 0.15 * | 0.24 ** | 0.15 * | 0.35 ** | 0.23 ** | 0.32 ** | -0.11 |
| **PL** | | | | | | | | 0.33 ** | 0.29 ** | 0.07 | 0.46 ** | 0.02 | 0.34 ** | 0.43 ** | 0.36 ** | 0.28 ** | 0.49 ** | -0.06 |
| **FLA** | | | | | | | | | 0.55 ** | -0.05 | 0.40 ** | 0.17 * | 0.24 ** | 0.07 | 0.38 ** | 0.34 ** | 0.30 ** | -0.12 |
| **SLA** | | | | | | | | | | -0.03 | 0.31 ** | 0.12 | 0.16 * | 0.1 | 0.21 ** | 0.20 ** | 0.21 ** | -0.06 |
| **SAng** | | | | | | | | | | | 0.07 | 0.24 ** | 0.13 | -0.15 * | 0.20 ** | 0.21 ** | 0.06 | -0.29 ** |
| **BPP** | | | | | | | | | | | | 0.48 ** | 0.38 ** | 0.13 | 0.48 ** | 0.41 ** | 0.40 ** | -0.34 ** |
| **YPP** | | | | | | | | | | | | | 0.50 ** | -0.29 ** | 0.61 ** | 0.61 ** | 0.26 ** | -0.70 ** |
| **TKW** | | | | | | | | | | | | | | 0.44 ** | 0.85 ** | 0.77 ** | 0.83 ** | -0.47 ** |
| **SL** | | | | | | | | | | | | | | | 0.26 ** | 0.13 * | 0.74 ** | 0.21 ** |
| **SW** | | | | | | | | | | | | | | | | 0.87 ** | 0.83 ** | -0.56 ** |
| **ST** | | | | | | | | | | | | | | | | | 0.66 ** | -0.58 ** |
| **SA** | | | | | | | | | | | | | | | | | | -0.27 ** |

*** Correlation is significant at 0.01 level; * Correlation is significant at 0.05 level.*

Supplementary Table S4: Principal component analysis for above ground traits of three environments.

| Traits | Environment 1 (E1) | | | | | Environment 2 (E2) | | | | | Environment 3 (E3) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PC1 | PC2 | PC3 | PC4 | PC5 | PC1 | PC2 | PC3 | PC4 | PC5 | PC1 | PC2 | PC3 | PC4 | PC5 | PC6 |
| **HT** | -0.70 | 0.12 | 0.51 | 0.43 | -0.05 | -0.19 | 0.86 | -0.22 | -0.17 | 0.19 | -0.72 | -0.08 | 0.42 | 0.13 | 0.37 | -0.09 |
| **FT** | -0.70 | 0.11 | 0.52 | 0.41 | -0.04 | -0.19 | 0.86 | -0.23 | -0.17 | 0.19 | -0.57 | -0.03 | 0.37 | 0.13 | 0.61 | 0.07 |
| **MT** | -0.66 | 0.10 | 0.44 | 0.37 | -0.04 | 0.11 | 0.80 | -0.26 | -0.14 | 0.12 | -0.45 | -0.09 | 0.60 | 0.11 | 0.29 | 0.12 |
| **PH** | 0.51 | 0.39 | 0.57 | 0.01 | -0.23 | 0.57 | 0.42 | -0.20 | 0.23 | 0.33 | 0.62 | 0.47 | 0.24 | 0.04 | 0.11 | 0.47 |
| **TTN** | -0.03 | 0.72 | -0.29 | 0.21 | 0.32 | -0.15 | 0.43 | 0.72 | 0.27 | -0.11 | -0.30 | -0.29 | -0.38 | 0.67 | -0.03 | 0.25 |
| **ETN** | -0.09 | 0.71 | -0.50 | 0.13 | 0.28 | -0.10 | 0.39 | 0.74 | 0.32 | -0.11 | -0.19 | -0.34 | -0.37 | 0.71 | 0.05 | 0.25 |
| **SpL** | 0.61 | 0.17 | 0.37 | -0.17 | -0.03 | 0.60 | -0.09 | -0.15 | 0.56 | -0.06 | 0.54 | 0.28 | 0.26 | 0.22 | -0.36 | 0.08 |
| **PL** | 0.55 | 0.48 | 0.26 | -0.23 | -0.10 | 0.49 | 0.10 | -0.20 | 0.51 | 0.25 | 0.64 | 0.52 | 0.13 | 0.05 | -0.02 | 0.36 |
| **FLA** | 0.77 | -0.09 | 0.15 | -0.23 | -0.07 | 0.70 | -0.22 | -0.22 | 0.24 | -0.17 | 0.51 | 0.15 | 0.30 | 0.37 | -0.34 | -0.40 |
| **SLA** | 0.78 | 0.01 | 0.39 | -0.16 | -0.09 | 0.77 | -0.22 | -0.24 | 0.31 | -0.09 | 0.31 | 0.18 | 0.53 | 0.39 | 0.05 | -0.37 |
| **SAng** | 0.32 | 0.33 | -0.21 | -0.18 | -0.29 | 0.15 | -0.08 | -0.03 | 0.22 | 0.61 | 0.20 | -0.26 | 0.23 | -0.45 | -0.01 | 0.41 |
| **BPP** | 0.32 | 0.81 | 0.10 | 0.22 | -0.07 | 0.16 | 0.71 | 0.18 | 0.22 | -0.08 | 0.63 | -0.04 | 0.33 | 0.31 | -0.09 | 0.25 |
| **YPP** | 0.54 | 0.57 | -0.17 | 0.25 | -0.12 | 0.47 | 0.32 | 0.50 | 0.16 | -0.09 | 0.52 | -0.71 | 0.18 | -0.01 | -0.11 | 0.01 |
| **TKW** | 0.78 | -0.17 | -0.09 | 0.44 | 0.17 | 0.80 | 0.09 | 0.21 | -0.39 | 0.09 | 0.82 | -0.21 | -0.17 | -0.05 | 0.35 | -0.13 |
| **SL** | 0.56 | -0.19 | 0.33 | 0.02 | 0.62 | 0.60 | 0.32 | -0.17 | -0.25 | -0.43 | 0.41 | 0.57 | -0.39 | 0.06 | 0.49 | -0.06 |
| **SW** | 0.74 | -0.30 | -0.11 | 0.45 | -0.08 | 0.80 | -0.12 | 0.27 | -0.35 | 0.18 | 0.89 | -0.30 | -0.05 | 0.01 | 0.18 | -0.09 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ST** | 0.57 | -0.21 | -0.17 | 0.34 | -0.21 | 0.70 | -0.11 | 0.32 | -0.34 | 0.14 | 0.78 | -0.40 | 0.03 | -0.01 | 0.20 | -0.11 |
| **SA** | 0.79 | -0.30 | 0.16 | 0.35 | 0.27 | 0.88 | 0.04 | 0.05 | -0.32 | -0.10 | 0.84 | 0.12 | -0.25 | 0.04 | 0.40 | -0.10 |
| **T** | -0.18 | 0.26 | 0.39 | -0.47 | 0.39 | 0.12 | 0.47 | -0.41 | 0.10 | -0.54 | -0.48 | 0.66 | -0.19 | 0.10 | -0.04 | -0.10 |
| **Eigen value** | 6.53 | 2.91 | 2.19 | 1.70 | 1.07 | 5.31 | 3.71 | 2.14 | 1.71 | 1.25 | 6.50 | 2.48 | 1.95 | 1.66 | 1.47 | 1.10 |
| **Proportional variance %** | 34.39 | 15.33 | 11.52 | 8.96 | 5.61 | 27.95 | 19.55 | 11.24 | 8.99 | 6.58 | 34.22 | 13.08 | 10.25 | 8.72 | 7.74 | 5.80 |
| **Cumulative variance %** | 34.39 | 49.72 | 61.24 | 70.20 | 75.81 | 27.95 | 47.50 | 58.75 | 67.74 | 74.32 | 34.22 | 47.29 | 57.55 | 66.27 | 74.01 | 79.81 |

Supplementary Table S5: Grouping of accessions using cluster analysis based on principal component analysis performed in three environments separately.

| Environ-ment | Cluster (% accession) | Accessions under corresponding cluster |
|---|---|---|
| E1 | 1 (26%) | TD16, TD18, TD19, TD22, TD23, TD28, TD37, TD42, TD43, TD46, TD50, TD55, TD60, TD66, TD69, TD70, TD72, TD73, TD74, TD75, TD78, TD82, TD87, TD89, TD98, TD101, TD112, TD118, TD125, TD135, TD137, TD166, TD181, TD246, TD260, TD263, TD268, TD283, TD310, TD314, TD326, TD380, TD386, TD403, TD407, TD409, TD410, TD413, TD415, TD453, TD460, TD522, TD543, TD646, TD694, TD721, TD743, TD761, TD764, TD767, TRTD04, TRTD06, TRTD07, TRTD13, TRTD26, TRTD27, TRTD40, TRTD41, TRTD54. |
| | 2 (23%) | TD12, TD13, TD20, TD21, TD24, TD26, TD38, TD39, TD44, TD45, TD48, TD53, TD54, TD56, TD61, TD71, TD81, TD84, TD90, TD95, TD106, TD110, TD123, TD126, TD130, TD139, TD140, TD141, TD148, TD164, TD165, TD216, TD301, TD316, TD317, TD383, TD392, TD393, TD405, TD416, TD419, TD421, TD422, TD459, TD464, TD517, TD518, TD526, TD546, TD554, TD734, TD768, TD770, TD771, TD774, TRTD12, TRTD16, TRTD37, TRTD66. |
| | 3 (12%) | TD14, TD35, TD120, TD121, 159, TD182, TD195, TD202, TD211, TD220, TD247, TD265, TD305, TD385, TD429, TD436, TD454, TD463, TD529, TD534, TD535, TD550, TD575, TD577, TD745, TD772, TRTD19, TRTD21, TRTD31, TRTD36, TRTD39, TRTD64, TRTD65. |
| | 4 (13%) | TD9, TD25, TD49, TD64, TD124, TD136, TD203, TD205, TD206, TD230, TD292, TD330, TD427, TD430, TD450, TD511, TD528, TD532, TD533, TD540, TD544, TD570, TD571, TD572, TD580, TD591, TD592, TD639, TD640, TRTD42, TRTD43, TRTD45, TRTD51, TRTD53, TRTD60. |
| | 5 (26%) | TD8, TD10, TD30, TD33, TD34, TD40, TD41, TD47, TD51, TD52, TD57, TD58, TD62, TD65, TD79, TD94, TD96, TD108, TD142, TD161, TD167, TD169, TD204, TD252, TD256, TD272, TD304, TD333, TD398, TD412, TD417, TD418, TD420, TD425, TD440, TD513, TD525, TD537, TD538, TD545, TD574, TD576, |

| | | |
|---|---|---|
| | | TD722, TD728, TD741, TD766, TD773, TRTD03, TRTD08, TRTD09, TRTD10, TRTD11, TRTD14, TRTD15, TRTD17, TRTD20, TRTD22, TRTD24, TRTD25, TRTD29, TRTD30, TRTD32, TRTD38, TRTD57, TRTD61, TRTD69. |
| E2 | 1 (42%) | TD10, TD13, TD16, TD20, TD21, TD22, TD24, TD25, TD28, TD34, TD41, TD47, TD52, TD54, TD56, TD58, TD62, TD64, TD65, TD71, TD78, TD79, TD81, TD82, TD98, TD120, TD121, TD126, TD136, TD159, TD166, TD182, TD202, TD203, TD204, TD205, TD206, TD211, TD220, TD230, TD247, TD265, TD268, TD305, TD316, TD330, TD333, TD383, TD386, TD398, TD407, TD410, TD412, TD417, TD420, TD427, TD429, TD430, TD436, TD454, TD511, TD522, TD540, TD546, TD550, TD570, TD571, TD572, TD574, TD577, TD580, TD591, TD592, TD640, TD651, TD694, TD722, TD745, TD773, TRTD37, TRTD43, TRTD45, TRTD51, TRTD53, TRTD54, TRTD60, TRTD61, TRTD64, TRTD69. |
| | 2 (34%) | TD8, TD9, TD12, TD19, TD26, TD37, TD38, TD39, TD42, TD43, TD44, TD45, TD46, TD48, TD50, TD53, TD55, TD57, TD61, TD69, TD72, TD73, TD74, TD75, TD90, TD95, TD96, TD101, TD123, TD124, TD125, TD135, TD139, TD140, TD195, TD216, TD246, TD260, TD263, TD272, TD301, TD304, TD310, TD314, TD317, TD380, TD392, TD393, TD409, TD413, TD415, TD416, TD418, TD440, TD450, TD459, TD463, TD464, TD517, TD529, TD543, TD544, TD554, TD639, TD721, TD728, TD761, TD764, TD768, TD770, TD771, TRTD07, TRTD12, TRTD42, TRTD57. |
| | 3 (13%) | TD23, TD66, TD89, TD94, TD106, TD110, TD112, TD118, TD142, TD148, TD164, TD165, TD167, TD169, TD181, TD252, TD256, TD419, TD421, TD422, TD453, TD576, TD734, TD743, TD767, TRTD03, TRTD04, TRTD08, TRTD10, TRTD41. |
| | 4 (11%) | TD425, TD534, TD535, TD741, TD766, TRTD06, TRTD09, TRTD11, TRTD13, TRTD14, TRTD16, TRTD19, TRTD20, TRTD21, TRTD22, TRTD26, TRTD29, TRTD30, TRTD32, TRTD38, TRTD39, TRTD40. |
| E3 | 1 (22%) | TD13, TD18, TD19, TD21, TD23, TD24, TD26, TD28, TD38, TD39, TD47, TD50, TD56, TD58, TD61, TD65, TD66, TD72, TD73, TD78, TD82, TD94, TD95, TD106, TD118, TD316, TD410, TD417, TD418, TD420, TD440, TD517, |

| | | |
|---|---|---|
| | | TD518, TD526, TD571, TD694, TD743, TD764, TD767, TRTD07, TRTD09, TRTD11, TRTD12, TRTD17, TRTD37, TRTD38. |
| | 2 (6%) | TD10, TD159, TD202, TD436, TD513, TD570, TD580, TD773, TRTD42, TRTD51, TRTD53, TRTD66, TRTD69. |
| | 3 (8%) | TD120, TD121, TD205, TD230, TD292, TD326, TD427, TD429, TD430, TD525, TD540, TD544, TD550, TD639, TD651, TRTD57. |
| | 4 (16%) | TD12, TD14, TD52, TD55, TD126, TD136, TD166, TD167, TD181, TD204, TD246, TD272, TD314, TD330, TD333, TD392, TD409, TD453, TD463, TD464, TD529, TD534, TD535, TD537, TD538, TD546, TD554, TD574, TD640, TD728, TD741, TD766, TRTD03, TRTD20, TRTD32. |
| | 5 (30%) | TD9, TD16, TD20, TD34, TD37, TD41, TD43, TD44, TD45, TD48, TD53, TD60, TD62, TD69, TD71, TD74, TD75, TD79, TD81, TD87, TD96, TD101, TD108, TD123, TD124, TD125, TD130, TD135, TD140, TD141, TD164, TD211, TD216, TD256, TD260, TD263, TD268, TD301, TD17, TD380, TD383, TD393, TD398, TD407, TD412, TD413, TD415, TD416, TD422, TD454, TD459, TD522, TD543, TD545, TD572, TD592, TD721, TD734, TD768, TD770, TD771, TD774, TRTD04, TRTD06, TRTD14, TRTD22, TRTD25, TRTD26, TRTD30. |
| | 6 (18%) | TD8, TD22, TD30, TD33, TD40, TD42, TD46, TD51, TD54, TD70, TD84, TD90, TD98, TD110, TD112, TD137, TD139, TD142, TD148, TD165, TD169, TD182, TD252, TD304, TD305, TD310, TD382, TD386, TD403, TD405, TD419, TD 21, TRTD08, TRTD10, TRTD15, TRTD16, TRTD19, TRTD24, TRTD27, TRTD41. |

Supplementary Table S6: Standardized genotype by yield*trait (GYT) data along with superiority index. Top 23 ranked genotypes are highlighted here. The trait abbreviations are Y: Yield; F: Flowering time; E: Effective tiller number; S: Spike length; FL: Flag leaf area; SA: Shoot angle; B: Biomass/plant; TKW: Thousand kernel weight; SW: Seed width; and T: Threshability.

| Genotypes | Y/F | Y*E | Y*S | Y*FL | Y*SA | Y*B | Y*TKW | Y*SW | Y/T | Mean superiority index |
|---|---|---|---|---|---|---|---|---|---|---|
| **TD534** | **6.82** | **5.33** | **6.16** | **2.34** | **5.77** | **7.64** | **8.01** | **6.90** | **6.49** | **6.16** |
| **Mace** | **5.26** | **4.18** | **4.16** | **9.33** | **5.06** | **3.29** | **4.79** | **4.86** | **5.24** | **5.13** |
| **TD120** | **4.98** | **6.11** | **5.51** | **1.14** | **5.84** | **6.12** | **3.82** | **5.09** | **6.29** | **4.99** |
| **Suntop** | **5.05** | **3.18** | **4.18** | **8.30** | **4.97** | **3.26** | **5.09** | **4.77** | **5.11** | **4.88** |
| **Yitpi** | **4.03** | **2.85** | **4.70** | **7.04** | **5.04** | **3.52** | **3.91** | **4.30** | **4.98** | **4.49** |
| **TD535** | **4.75** | **4.37** | **4.35** | **1.48** | **3.75** | **3.77** | **5.40** | **4.75** | **4.66** | **4.14** |
| **TD121** | **3.39** | **4.38** | **4.01** | **0.77** | **3.80** | **3.09** | **2.78** | **3.52** | **4.66** | **3.38** |
| **TD8** | **1.87** | **1.32** | **2.31** | **0.26** | **2.45** | **3.10** | **1.62** | **1.99** | **0.78** | **1.74** |
| **TD9** | **1.75** | **2.52** | **1.77** | **0.24** | **2.00** | **2.06** | **2.03** | **2.01** | **1.20** | **1.73** |
| **TD70** | **1.38** | **1.79** | **2.01** | **0.33** | **1.21** | **2.53** | **1.33** | **1.42** | **0.40** | **1.38** |
| **TD453** | **1.28** | **2.35** | **1.18** | **0.04** | **1.51** | **1.14** | **0.99** | **1.43** | **0.85** | **1.20** |
| **TD216** | **1.34** | **1.85** | **1.19** | **0.23** | **1.03** | **1.15** | **1.21** | **1.15** | **0.61** | **1.08** |
| **TD166** | **1.14** | **2.06** | **1.03** | **0.01** | **1.22** | **1.22** | **0.62** | **1.18** | **1.07** | **1.06** |
| **TD110** | **1.24** | **0.70** | **1.52** | **0.20** | **0.98** | **1.88** | **1.06** | **1.28** | **0.34** | **1.02** |
| **TD256** | **1.07** | **1.61** | **0.86** | **0.06** | **1.05** | **1.13** | **1.12** | **1.02** | **0.26** | **0.91** |
| **TD574** | **0.87** | **2.08** | **1.17** | **0.04** | **1.19** | **1.06** | **0.53** | **0.86** | **0.28** | **0.90** |
| **TD743** | **0.68** | **2.09** | **0.77** | **-0.10** | **0.12** | **1.00** | **1.00** | **0.68** | **0.11** | **0.71** |
| **TD771** | **0.69** | **0.54** | **0.86** | **0.10** | **0.67** | **0.96** | **0.79** | **0.77** | **0.13** | **0.61** |
| **TD454** | **0.51** | **0.47** | **1.20** | **-0.09** | **0.98** | **1.12** | **0.10** | **0.51** | **0.42** | **0.58** |
| **TD74** | **0.74** | **0.19** | **0.98** | **0.20** | **0.98** | **0.51** | **0.58** | **0.84** | **0.17** | **0.58** |
| **TD130** | **0.63** | **0.47** | **0.87** | **0.02** | **0.66** | **0.62** | **0.64** | **0.64** | **0.11** | **0.52** |
| **TD112** | **0.55** | **0.22** | **0.85** | **0.07** | **0.22** | **0.82** | **0.55** | **0.58** | **0.08** | **0.44** |
| **TD123** | **0.51** | **0.43** | **0.84** | **0.03** | **0.59** | **0.40** | **0.42** | **0.41** | **0.05** | **0.41** |
| TD263 | 0.23 | 0.42 | 0.40 | 0.00 | 0.39 | 0.15 | 0.24 | 0.29 | 0.93 | 0.34 |
| TD518 | 0.36 | 0.43 | 0.44 | -0.04 | 0.16 | 0.68 | 0.48 | 0.36 | 0.00 | 0.32 |
| TD463 | 0.20 | 1.11 | 0.31 | 0.08 | 0.36 | 0.21 | 0.18 | 0.24 | -0.02 | 0.30 |
| TD405 | 0.34 | -0.03 | 0.44 | -0.07 | 0.53 | 0.52 | 0.41 | 0.31 | -0.01 | 0.27 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| TD55 | 0.34 | 0.64 | 0.25 | -0.11 | 0.32 | 0.28 | 0.21 | 0.34 | 0.00 | 0.25 |
| TRTD16 | 0.37 | 0.70 | 0.36 | -0.06 | 0.06 | 0.14 | 0.21 | 0.30 | 0.00 | 0.23 |
| TD34 | 0.23 | 0.41 | 0.32 | 0.00 | 0.35 | 0.47 | 0.13 | 0.20 | -0.04 | 0.23 |
| TD592 | 0.26 | 0.90 | 0.15 | -0.19 | 0.33 | 0.25 | 0.14 | 0.18 | 0.01 | 0.23 |
| TD51 | 0.20 | 0.49 | 0.36 | -0.06 | 0.27 | 0.35 | 0.22 | 0.21 | -0.06 | 0.22 |
| TRTD24 | 0.36 | -0.01 | 0.45 | 0.06 | 0.18 | 0.32 | 0.31 | 0.31 | 0.01 | 0.22 |
| TRTD37 | 0.23 | 0.99 | 0.16 | -0.07 | -0.10 | 0.24 | 0.20 | 0.25 | -0.04 | 0.21 |
| TD56 | 0.15 | 0.30 | 0.40 | 0.00 | 0.02 | 0.47 | 0.10 | 0.14 | -0.07 | 0.17 |
| TD22 | 0.19 | 0.35 | 0.23 | 0.07 | 0.04 | 0.20 | 0.22 | 0.19 | -0.05 | 0.16 |
| TD24 | 0.16 | 0.85 | 0.19 | -0.06 | -0.03 | 0.11 | 0.12 | 0.15 | -0.07 | 0.16 |
| TD30 | 0.15 | 0.40 | 0.29 | -0.04 | 0.01 | 0.46 | 0.05 | 0.17 | -0.07 | 0.16 |
| TD60 | 0.15 | 0.29 | 0.14 | -0.13 | 0.36 | 0.25 | 0.11 | 0.16 | -0.07 | 0.14 |
| TD392 | 0.14 | 0.10 | 0.31 | -0.02 | 0.21 | 0.34 | 0.11 | 0.14 | -0.08 | 0.14 |
| TD54 | 0.24 | 0.35 | 0.40 | -0.14 | 0.00 | 0.14 | 0.13 | 0.18 | -0.12 | 0.13 |
| TD125 | 0.08 | 0.37 | 0.30 | -0.12 | 0.06 | 0.32 | 0.08 | 0.09 | -0.10 | 0.12 |
| TD33 | 0.18 | -0.06 | 0.34 | 0.06 | -0.15 | 0.36 | 0.15 | 0.15 | -0.06 | 0.11 |
| TD62 | 0.01 | 0.09 | -0.07 | -0.09 | 0.32 | 0.09 | 0.34 | 0.21 | -0.09 | 0.09 |
| TD13 | 0.09 | 0.08 | 0.31 | 0.04 | -0.05 | 0.21 | 0.03 | 0.05 | -0.08 | 0.07 |
| TRTD22 | 0.14 | -0.11 | 0.08 | -0.09 | 0.22 | 0.02 | 0.24 | 0.17 | -0.08 | 0.07 |
| TD330 | 0.09 | 0.31 | -0.04 | -0.22 | -0.05 | -0.05 | 0.19 | 0.06 | 0.16 | 0.05 |
| TD305 | 0.04 | 0.13 | 0.35 | 0.03 | -0.29 | 0.20 | 0.07 | 0.03 | -0.12 | 0.05 |
| TD169 | 0.03 | 0.50 | 0.09 | -0.06 | 0.00 | -0.08 | 0.08 | -0.01 | -0.12 | 0.05 |
| TD382 | 0.04 | 0.24 | 0.22 | -0.03 | -0.23 | 0.23 | 0.01 | 0.07 | -0.12 | 0.05 |
| TRTD15 | 0.02 | 0.15 | 0.13 | 0.05 | -0.13 | 0.28 | -0.05 | -0.04 | -0.12 | 0.03 |
| TD386 | 0.03 | 0.24 | 0.11 | -0.03 | -0.35 | 0.21 | 0.14 | 0.04 | -0.13 | 0.03 |
| TD84 | 0.05 | 0.01 | 0.13 | -0.06 | 0.14 | -0.08 | 0.08 | 0.07 | -0.11 | 0.03 |
| TD108 | 0.04 | 0.07 | -0.02 | -0.08 | 0.08 | 0.12 | 0.04 | 0.07 | -0.12 | 0.02 |
| TD766 | 0.07 | 0.29 | -0.15 | -0.18 | -0.06 | 0.10 | 0.05 | 0.08 | -0.11 | 0.01 |
| TD417 | 0.05 | 0.07 | 0.09 | -0.08 | -0.10 | 0.05 | 0.00 | 0.03 | -0.12 | 0.00 |
| TD202 | 0.11 | 0.54 | 0.12 | -0.19 | -0.17 | -0.27 | -0.02 | 0.02 | -0.19 | -0.01 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| TD164 | 0.02 | 0.13 | -0.06 | -0.08 | 0.00 | 0.00 | 0.04 | 0.01 | -0.12 | -0.01 |
| TD87 | 0.05 | -0.09 | 0.07 | -0.06 | 0.01 | 0.08 | -0.06 | 0.03 | -0.11 | -0.01 |
| TD464 | 0.05 | -0.26 | 0.24 | -0.05 | 0.08 | -0.15 | 0.04 | 0.04 | -0.11 | -0.01 |
| TD418 | -0.03 | 0.44 | -0.05 | -0.14 | -0.30 | 0.29 | -0.14 | -0.06 | -0.14 | -0.01 |
| TD101 | 0.01 | -0.11 | 0.11 | -0.09 | 0.10 | -0.06 | 0.00 | 0.02 | -0.12 | -0.01 |
| TD768 | -0.01 | 0.02 | -0.01 | -0.14 | 0.07 | -0.09 | 0.06 | 0.05 | -0.13 | -0.02 |
| TD413 | -0.04 | -0.16 | 0.01 | -0.07 | 0.09 | 0.05 | 0.03 | 0.01 | -0.14 | -0.02 |
| TD61 | -0.10 | 0.07 | 0.06 | -0.05 | -0.23 | -0.13 | 0.25 | 0.05 | -0.14 | -0.03 |
| TD517 | -0.01 | -0.03 | 0.05 | -0.06 | -0.13 | 0.02 | 0.00 | 0.00 | -0.14 | -0.03 |
| TD734 | 0.05 | -0.08 | -0.10 | -0.13 | 0.06 | 0.01 | -0.04 | 0.03 | -0.11 | -0.04 |
| TD571 | -0.10 | 0.36 | -0.01 | -0.13 | -0.16 | -0.03 | -0.02 | -0.12 | -0.13 | -0.04 |
| TD19 | -0.01 | -0.08 | -0.04 | -0.14 | -0.14 | 0.16 | -0.01 | -0.01 | -0.14 | -0.04 |
| TD79 | 0.01 | -0.07 | 0.02 | -0.13 | 0.01 | -0.01 | -0.10 | -0.04 | -0.14 | -0.05 |
| TD42 | -0.03 | 0.08 | 0.04 | -0.12 | -0.13 | 0.04 | -0.17 | -0.02 | -0.14 | -0.05 |
| TD140 | -0.02 | -0.08 | 0.02 | -0.05 | 0.04 | -0.12 | -0.11 | -0.02 | -0.14 | -0.05 |
| TD639 | -0.03 | -0.09 | -0.11 | -0.23 | 0.19 | -0.12 | 0.09 | -0.08 | -0.11 | -0.05 |
| TD304 | -0.02 | -0.16 | 0.09 | -0.15 | -0.19 | 0.06 | -0.01 | -0.05 | -0.14 | -0.06 |
| TD139 | -0.07 | -0.08 | 0.02 | -0.09 | -0.07 | 0.19 | -0.24 | -0.11 | -0.15 | -0.07 |
| TD421 | -0.17 | 0.31 | -0.01 | -0.11 | -0.30 | 0.05 | -0.08 | -0.13 | -0.20 | -0.07 |
| TD537 | -0.11 | 0.43 | -0.07 | -0.22 | -0.08 | -0.32 | -0.04 | -0.08 | -0.17 | -0.07 |
| TD416 | -0.05 | -0.34 | -0.12 | -0.07 | 0.11 | -0.01 | -0.08 | -0.03 | -0.15 | -0.08 |
| TD12 | -0.12 | 0.40 | -0.12 | -0.08 | -0.01 | -0.28 | -0.23 | -0.16 | -0.18 | -0.09 |
| TD316 | -0.08 | -0.12 | -0.01 | -0.04 | -0.18 | -0.16 | 0.00 | -0.04 | -0.16 | -0.09 |
| TD764 | -0.16 | 0.44 | -0.06 | -0.10 | -0.34 | 0.16 | -0.33 | -0.23 | -0.19 | -0.09 |
| TD37 | -0.13 | 0.08 | -0.21 | -0.17 | -0.07 | -0.08 | 0.03 | -0.10 | -0.17 | -0.09 |
| TRTD41 | -0.16 | 0.34 | -0.18 | -0.03 | -0.12 | -0.08 | -0.24 | -0.24 | -0.19 | -0.10 |
| TD73 | -0.16 | -0.14 | -0.16 | 0.01 | -0.18 | -0.08 | -0.02 | -0.06 | -0.17 | -0.11 |
| TD142 | -0.10 | -0.01 | -0.12 | -0.17 | -0.18 | -0.12 | -0.13 | -0.09 | -0.17 | -0.12 |
| TD721 | -0.09 | -0.22 | -0.11 | -0.12 | -0.08 | -0.13 | -0.12 | -0.06 | -0.16 | -0.12 |
| TD46 | -0.16 | -0.05 | -0.11 | -0.07 | -0.19 | -0.02 | -0.16 | -0.16 | -0.18 | -0.12 |

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|---|---|---|---|---|---|---|---|---|---|---|
| TD546 | -0.08 | 0.03 | -0.19 | -0.21 | -0.08 | -0.21 | -0.10 | -0.14 | -0.21 | -0.13 |
| TD106 | -0.11 | -0.22 | -0.17 | -0.11 | -0.18 | 0.03 | -0.15 | -0.12 | -0.17 | -0.13 |
| TD260 | -0.11 | -0.11 | -0.22 | -0.08 | -0.05 | -0.21 | -0.19 | -0.14 | -0.17 | -0.14 |
| TD380 | -0.17 | -0.27 | -0.17 | -0.11 | -0.10 | 0.00 | -0.14 | -0.15 | -0.18 | -0.14 |
| TD141 | -0.13 | -0.29 | -0.13 | -0.17 | -0.07 | 0.01 | -0.17 | -0.15 | -0.19 | -0.14 |
| TD90 | -0.13 | -0.40 | -0.12 | -0.11 | -0.05 | -0.06 | -0.10 | -0.15 | -0.18 | -0.14 |
| TD159 | -0.06 | -0.19 | -0.08 | -0.09 | -0.38 | -0.24 | -0.08 | -0.11 | -0.15 | -0.15 |
| TD136 | -0.10 | -0.41 | -0.28 | -0.18 | 0.03 | -0.14 | -0.11 | -0.12 | -0.15 | -0.16 |
| TD182 | -0.17 | -0.50 | -0.25 | -0.04 | -0.02 | 0.09 | -0.22 | -0.18 | -0.20 | -0.16 |
| TD393 | -0.19 | 0.08 | -0.17 | -0.20 | -0.23 | -0.17 | -0.20 | -0.20 | -0.20 | -0.17 |
| TD403 | -0.17 | -0.31 | -0.17 | -0.19 | -0.08 | -0.12 | -0.13 | -0.14 | -0.20 | -0.17 |
| TD40 | -0.17 | -0.31 | -0.13 | -0.13 | -0.12 | -0.16 | -0.10 | -0.18 | -0.20 | -0.17 |
| TD526 | -0.13 | -0.26 | 0.01 | -0.15 | -0.30 | -0.23 | -0.09 | -0.18 | -0.18 | -0.17 |
| TD572 | -0.22 | 0.13 | -0.28 | -0.19 | -0.08 | -0.22 | -0.26 | -0.24 | -0.19 | -0.17 |
| TD165 | -0.09 | -0.31 | -0.13 | -0.12 | -0.16 | -0.26 | -0.17 | -0.14 | -0.17 | -0.17 |
| TD71 | -0.12 | -0.33 | -0.15 | -0.15 | 0.00 | -0.29 | -0.18 | -0.19 | -0.18 | -0.18 |
| TD383 | -0.15 | -0.27 | -0.17 | -0.10 | 0.00 | -0.27 | -0.31 | -0.19 | -0.18 | -0.18 |
| TD20 | -0.16 | -0.50 | -0.10 | -0.13 | -0.03 | -0.07 | -0.23 | -0.23 | -0.23 | -0.19 |
| TD148 | -0.27 | -0.21 | -0.17 | -0.09 | -0.15 | 0.02 | -0.28 | -0.29 | -0.23 | -0.19 |
| TD543 | -0.23 | -0.42 | -0.18 | -0.14 | -0.12 | -0.17 | -0.15 | -0.19 | -0.22 | -0.20 |
| TD407 | -0.22 | -0.16 | -0.18 | -0.14 | -0.13 | -0.40 | -0.15 | -0.23 | -0.21 | -0.20 |
| TD65 | -0.18 | -0.31 | -0.19 | -0.16 | -0.32 | -0.12 | -0.17 | -0.23 | -0.20 | -0.21 |
| TRTD08 | -0.21 | -0.43 | -0.18 | -0.10 | -0.21 | -0.22 | -0.21 | -0.23 | -0.21 | -0.22 |
| TD137 | -0.19 | -0.51 | -0.17 | -0.14 | -0.38 | -0.18 | -0.10 | -0.17 | -0.20 | -0.23 |
| TD205 | -0.17 | -0.15 | -0.28 | -0.24 | -0.14 | -0.44 | -0.18 | -0.24 | -0.25 | -0.23 |
| TD78 | -0.20 | -0.46 | -0.17 | -0.15 | -0.22 | -0.26 | -0.22 | -0.18 | -0.21 | -0.23 |
| TRTD07 | -0.24 | -0.46 | -0.14 | -0.11 | -0.29 | -0.15 | -0.25 | -0.24 | -0.22 | -0.24 |
| TD252 | -0.21 | -0.36 | -0.30 | -0.15 | -0.15 | -0.40 | -0.14 | -0.21 | -0.22 | -0.24 |
| TD773 | -0.19 | -0.25 | -0.19 | -0.12 | -0.45 | -0.34 | -0.23 | -0.20 | -0.18 | -0.24 |
| TD314 | -0.25 | -0.37 | -0.23 | -0.13 | -0.16 | -0.34 | -0.23 | -0.28 | -0.22 | -0.25 |

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|---|---|---|---|---|---|---|---|---|---|---|
| TD28 | -0.27 | -0.27 | -0.20 | -0.10 | -0.40 | -0.10 | -0.34 | -0.31 | -0.23 | -0.25 |
| TD21 | -0.24 | -0.49 | -0.29 | -0.16 | -0.26 | -0.27 | -0.11 | -0.24 | -0.22 | -0.25 |
| TD43 | -0.28 | -0.34 | -0.32 | -0.17 | -0.18 | -0.25 | -0.30 | -0.27 | -0.23 | -0.26 |
| TD26 | -0.26 | -0.28 | -0.22 | -0.10 | -0.29 | -0.30 | -0.37 | -0.29 | -0.23 | -0.26 |
| TD124 | -0.30 | -0.44 | -0.19 | -0.11 | -0.21 | -0.08 | -0.41 | -0.34 | -0.25 | -0.26 |
| TD741 | -0.24 | -0.18 | -0.32 | -0.16 | -0.21 | -0.40 | -0.33 | -0.31 | -0.22 | -0.26 |
| TD23 | -0.32 | -0.28 | -0.24 | -0.20 | -0.37 | -0.13 | -0.28 | -0.33 | -0.25 | -0.27 |
| TD72 | -0.28 | -0.42 | -0.26 | -0.14 | -0.29 | -0.39 | -0.23 | -0.19 | -0.22 | -0.27 |
| TRTD17 | -0.19 | -0.55 | -0.24 | -0.16 | -0.35 | -0.37 | -0.13 | -0.24 | -0.22 | -0.27 |
| TD204 | -0.29 | 0.08 | -0.43 | -0.27 | -0.32 | -0.56 | -0.20 | -0.26 | -0.20 | -0.27 |
| TD47 | -0.31 | -0.44 | -0.31 | -0.17 | -0.43 | -0.27 | -0.12 | -0.29 | -0.25 | -0.29 |
| TD50 | -0.31 | -0.26 | -0.24 | -0.15 | -0.48 | -0.28 | -0.31 | -0.32 | -0.25 | -0.29 |
| TD272 | -0.28 | -0.42 | -0.21 | -0.21 | -0.29 | -0.47 | -0.21 | -0.28 | -0.24 | -0.29 |
| TRTD11 | -0.26 | -0.38 | -0.33 | -0.16 | -0.39 | -0.22 | -0.34 | -0.30 | -0.23 | -0.29 |
| TD640 | -0.29 | -0.15 | -0.42 | -0.28 | -0.29 | -0.26 | -0.43 | -0.33 | -0.21 | -0.30 |
| TRTD12 | -0.33 | 0.05 | -0.42 | -0.20 | -0.39 | -0.44 | -0.34 | -0.31 | -0.29 | -0.30 |
| TD774 | -0.30 | -0.37 | -0.40 | -0.17 | -0.25 | -0.43 | -0.24 | -0.29 | -0.24 | -0.30 |
| TD66 | -0.31 | -0.26 | -0.27 | -0.18 | -0.35 | -0.36 | -0.35 | -0.35 | -0.27 | -0.30 |
| TD545 | -0.28 | -0.37 | -0.43 | -0.23 | -0.25 | -0.45 | -0.21 | -0.31 | -0.22 | -0.31 |
| TRTD06 | -0.27 | -0.49 | -0.41 | -0.18 | -0.22 | -0.45 | -0.27 | -0.25 | -0.23 | -0.31 |
| TRTD57 | -0.37 | -0.03 | -0.34 | -0.15 | -0.20 | -0.58 | -0.43 | -0.36 | -0.33 | -0.31 |
| TRTD04 | -0.31 | -0.44 | -0.35 | -0.19 | -0.14 | -0.40 | -0.41 | -0.35 | -0.25 | -0.31 |
| TD410 | -0.29 | -0.42 | -0.42 | -0.18 | -0.55 | -0.30 | -0.19 | -0.25 | -0.24 | -0.32 |
| TD412 | -0.33 | -0.62 | -0.29 | -0.21 | -0.27 | -0.30 | -0.26 | -0.33 | -0.25 | -0.32 |
| TD53 | -0.34 | -0.35 | -0.38 | -0.19 | -0.34 | -0.31 | -0.35 | -0.35 | -0.26 | -0.32 |
| TRTD10 | -0.32 | -0.33 | -0.40 | -0.20 | -0.29 | -0.36 | -0.41 | -0.38 | -0.25 | -0.33 |
| TD118 | -0.33 | -0.38 | -0.34 | -0.20 | -0.42 | -0.39 | -0.30 | -0.33 | -0.26 | -0.33 |
| TD75 | -0.36 | -0.49 | -0.36 | -0.18 | -0.32 | -0.28 | -0.34 | -0.35 | -0.27 | -0.33 |
| TRTD20 | -0.30 | -0.36 | -0.53 | -0.24 | -0.33 | -0.41 | -0.26 | -0.30 | -0.25 | -0.33 |
| TD230 | -0.45 | -0.08 | -0.48 | -0.15 | -0.40 | -0.28 | -0.48 | -0.41 | -0.28 | -0.33 |

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|---|---|---|---|---|---|---|---|---|---|---|
| TD333 | -0.34 | -0.29 | -0.33 | -0.23 | -0.25 | -0.41 | -0.45 | -0.41 | -0.32 | -0.34 |
| TD69 | -0.38 | -0.45 | -0.32 | -0.20 | -0.27 | -0.36 | -0.38 | -0.39 | -0.28 | -0.34 |
| TD459 | -0.35 | -0.58 | -0.32 | -0.17 | -0.30 | -0.36 | -0.34 | -0.36 | -0.26 | -0.34 |
| TD39 | -0.35 | -0.42 | -0.37 | -0.19 | -0.52 | -0.30 | -0.32 | -0.35 | -0.26 | -0.34 |
| TRTD30 | -0.40 | -0.22 | -0.38 | -0.20 | -0.32 | -0.47 | -0.45 | -0.41 | -0.28 | -0.35 |
| TRTD38 | -0.37 | -0.42 | -0.39 | -0.17 | -0.42 | -0.49 | -0.23 | -0.38 | -0.27 | -0.35 |
| TD211 | -0.41 | -0.24 | -0.49 | -0.20 | -0.16 | -0.47 | -0.46 | -0.43 | -0.29 | -0.35 |
| TD317 | -0.34 | -0.62 | -0.34 | -0.20 | -0.25 | -0.54 | -0.29 | -0.32 | -0.26 | -0.35 |
| TD651 | -0.39 | -0.20 | -0.58 | -0.26 | -0.15 | -0.61 | -0.37 | -0.39 | -0.25 | -0.35 |
| TD58 | -0.40 | -0.45 | -0.38 | -0.18 | -0.49 | -0.31 | -0.36 | -0.39 | -0.28 | -0.36 |
| TD419 | -0.41 | -0.52 | -0.36 | -0.11 | -0.45 | -0.37 | -0.41 | -0.37 | -0.28 | -0.36 |
| TD95 | -0.36 | -0.43 | -0.37 | -0.19 | -0.41 | -0.51 | -0.39 | -0.37 | -0.27 | -0.37 |
| TD268 | -0.41 | -0.52 | -0.37 | -0.22 | -0.23 | -0.52 | -0.42 | -0.41 | -0.28 | -0.38 |
| TD522 | -0.44 | -0.66 | -0.34 | -0.25 | -0.23 | -0.48 | -0.40 | -0.39 | -0.23 | -0.38 |
| TD529 | -0.42 | -0.28 | -0.53 | -0.26 | -0.31 | -0.52 | -0.39 | -0.44 | -0.28 | -0.38 |
| TD45 | -0.48 | -0.21 | -0.55 | -0.23 | -0.41 | -0.46 | -0.37 | -0.44 | -0.31 | -0.38 |
| TD301 | -0.43 | -0.69 | -0.41 | -0.17 | -0.37 | -0.38 | -0.39 | -0.40 | -0.29 | -0.39 |
| TD44 | -0.47 | -0.53 | -0.44 | -0.20 | -0.39 | -0.48 | -0.41 | -0.44 | -0.31 | -0.41 |
| TRTD19 | -0.46 | -0.58 | -0.47 | -0.22 | -0.45 | -0.44 | -0.42 | -0.45 | -0.30 | -0.42 |
| TD310 | -0.50 | -0.53 | -0.46 | -0.21 | -0.50 | -0.35 | -0.45 | -0.48 | -0.32 | -0.42 |
| TD94 | -0.44 | -0.58 | -0.45 | -0.22 | -0.52 | -0.42 | -0.45 | -0.46 | -0.30 | -0.43 |
| TD694 | -0.49 | -0.53 | -0.42 | -0.13 | -0.61 | -0.40 | -0.45 | -0.48 | -0.34 | -0.43 |
| TD98 | -0.40 | -0.61 | -0.47 | -0.23 | -0.48 | -0.56 | -0.41 | -0.40 | -0.29 | -0.43 |
| TRTD27 | -0.47 | -0.68 | -0.46 | -0.21 | -0.46 | -0.58 | -0.28 | -0.43 | -0.31 | -0.43 |
| TD41 | -0.44 | -0.69 | -0.44 | -0.23 | -0.40 | -0.49 | -0.46 | -0.44 | -0.29 | -0.43 |
| TD52 | -0.45 | -0.57 | -0.52 | -0.22 | -0.38 | -0.52 | -0.44 | -0.48 | -0.30 | -0.43 |
| TRTD03 | -0.49 | -0.48 | -0.50 | -0.24 | -0.37 | -0.49 | -0.53 | -0.49 | -0.31 | -0.43 |
| TRTD25 | -0.48 | -0.66 | -0.53 | -0.20 | -0.33 | -0.53 | -0.40 | -0.49 | -0.31 | -0.44 |
| TD429 | -0.45 | -0.54 | -0.61 | -0.27 | -0.29 | -0.55 | -0.51 | -0.47 | -0.24 | -0.44 |
| TD409 | -0.46 | -0.71 | -0.47 | -0.21 | -0.37 | -0.58 | -0.44 | -0.44 | -0.30 | -0.44 |

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|---|---|---|---|---|---|---|---|---|---|---|
| TD420 | -0.43 | -0.56 | -0.62 | -0.16 | -0.48 | -0.59 | -0.46 | -0.45 | -0.30 | -0.45 |
| TD82 | -0.50 | -0.53 | -0.50 | -0.22 | -0.56 | -0.44 | -0.49 | -0.49 | -0.34 | -0.45 |
| TD14 | -0.51 | -0.51 | -0.54 | -0.23 | -0.44 | -0.43 | -0.55 | -0.55 | -0.33 | -0.46 |
| TD770 | -0.50 | -0.61 | -0.54 | -0.21 | -0.43 | -0.52 | -0.47 | -0.49 | -0.34 | -0.46 |
| TRTD09 | -0.47 | -0.59 | -0.52 | -0.22 | -0.54 | -0.52 | -0.46 | -0.49 | -0.31 | -0.46 |
| TD415 | -0.53 | -0.76 | -0.64 | -0.21 | -0.42 | -0.54 | -0.28 | -0.43 | -0.33 | -0.46 |
| TD540 | -0.53 | -0.33 | -0.64 | -0.21 | -0.50 | -0.68 | -0.46 | -0.50 | -0.31 | -0.46 |
| TD48 | -0.50 | -0.67 | -0.55 | -0.23 | -0.47 | -0.58 | -0.37 | -0.46 | -0.33 | -0.46 |
| TD18 | -0.50 | -0.70 | -0.48 | -0.18 | -0.51 | -0.51 | -0.48 | -0.49 | -0.34 | -0.47 |
| TD398 | -0.52 | -0.44 | -0.57 | -0.25 | -0.46 | -0.54 | -0.56 | -0.56 | -0.35 | -0.47 |
| TD167 | -0.50 | -0.74 | -0.49 | -0.24 | -0.46 | -0.63 | -0.41 | -0.49 | -0.32 | -0.47 |
| TD246 | -0.52 | -0.64 | -0.62 | -0.23 | -0.46 | -0.52 | -0.48 | -0.50 | -0.33 | -0.48 |
| TD513 | -0.43 | -0.68 | -0.56 | -0.28 | -0.57 | -0.54 | -0.49 | -0.47 | -0.32 | -0.48 |
| TD16 | -0.51 | -0.56 | -0.61 | -0.24 | -0.50 | -0.58 | -0.51 | -0.51 | -0.33 | -0.48 |
| TD554 | -0.61 | -0.67 | -0.64 | -0.22 | -0.52 | -0.29 | -0.57 | -0.61 | -0.36 | -0.50 |
| TD422 | -0.56 | -0.68 | -0.56 | -0.23 | -0.49 | -0.55 | -0.52 | -0.58 | -0.34 | -0.50 |
| TD767 | -0.53 | -0.65 | -0.64 | -0.22 | -0.68 | -0.53 | -0.46 | -0.49 | -0.33 | -0.50 |
| TD81 | -0.58 | -0.58 | -0.64 | -0.24 | -0.42 | -0.66 | -0.55 | -0.56 | -0.35 | -0.51 |
| TD427 | -0.51 | -0.63 | -0.65 | -0.29 | -0.43 | -0.62 | -0.58 | -0.55 | -0.33 | -0.51 |
| TD728 | -0.63 | -0.65 | -0.69 | -0.26 | -0.52 | -0.63 | -0.46 | -0.56 | -0.37 | -0.53 |
| TD38 | -0.59 | -0.60 | -0.69 | -0.21 | -0.70 | -0.58 | -0.50 | -0.57 | -0.38 | -0.53 |
| TD440 | -0.59 | -0.73 | -0.62 | -0.24 | -0.58 | -0.62 | -0.56 | -0.56 | -0.33 | -0.54 |
| TRTD42 | -0.41 | -0.76 | -0.53 | -0.20 | -0.71 | -0.66 | -0.66 | -0.60 | -0.38 | -0.54 |
| TD580 | -0.64 | -0.61 | -0.73 | -0.27 | -0.68 | -0.56 | -0.60 | -0.62 | -0.36 | -0.56 |
| TRTD26 | -0.64 | -0.76 | -0.68 | -0.25 | -0.55 | -0.72 | -0.58 | -0.64 | -0.37 | -0.58 |
| TD135 | -0.64 | -0.85 | -0.70 | -0.29 | -0.55 | -0.66 | -0.53 | -0.62 | -0.37 | -0.58 |
| TD544 | -0.67 | -0.80 | -0.76 | -0.30 | -0.53 | -0.66 | -0.50 | -0.64 | -0.37 | -0.58 |
| TD126 | -0.67 | -0.78 | -0.71 | -0.26 | -0.60 | -0.63 | -0.55 | -0.65 | -0.38 | -0.58 |
| TD550 | -0.67 | -0.70 | -0.75 | -0.25 | -0.56 | -0.72 | -0.60 | -0.63 | -0.39 | -0.59 |
| TD430 | -0.66 | -0.60 | -0.76 | -0.28 | -0.58 | -0.75 | -0.60 | -0.67 | -0.38 | -0.59 |

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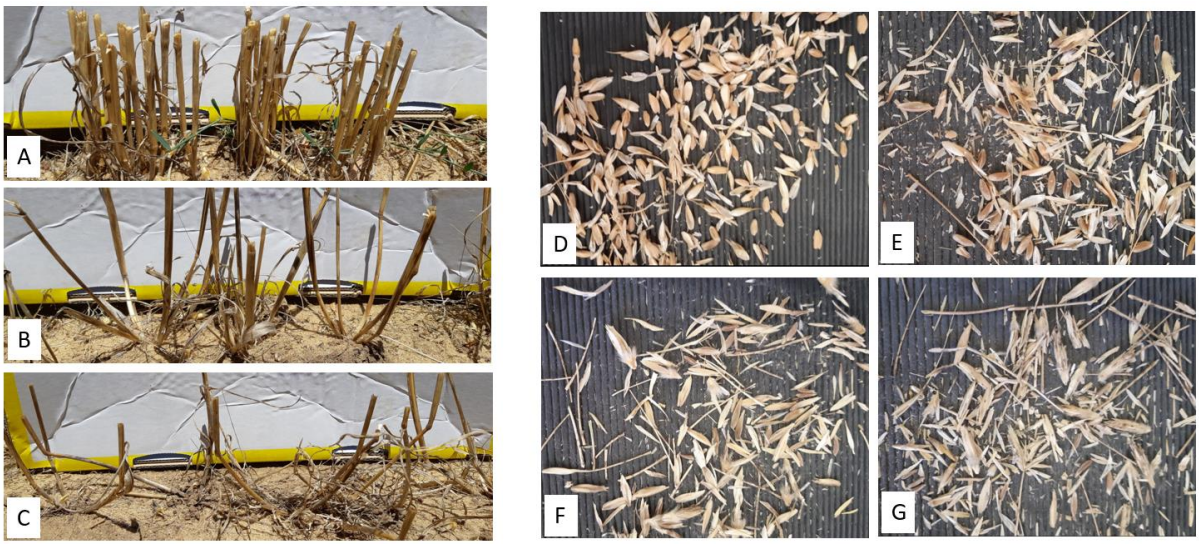
|---|---|---|---|---|---|---|---|---|---|---|
| TD538 | -0.66 | -0.77 | -0.70 | -0.30 | -0.57 | -0.64 | -0.61 | -0.65 | -0.38 | -0.59 |
| TD525 | -0.66 | -0.76 | -0.77 | -0.23 | -0.60 | -0.55 | -0.67 | -0.67 | -0.41 | -0.59 |
| TD96 | -0.70 | -0.58 | -0.80 | -0.28 | -0.65 | -0.73 | -0.58 | -0.66 | -0.40 | -0.60 |
| TD326 | -0.65 | -0.62 | -0.79 | -0.30 | -0.59 | -0.69 | -0.69 | -0.69 | -0.41 | -0.60 |
| TRTD69 | -0.66 | -0.60 | -0.80 | -0.31 | -0.75 | -0.62 | -0.63 | -0.67 | -0.38 | -0.60 |
| TRTD53 | -0.69 | -0.54 | -0.73 | -0.25 | -0.80 | -0.70 | -0.67 | -0.68 | -0.39 | -0.60 |
| TRTD14 | -0.70 | -0.74 | -0.71 | -0.27 | -0.63 | -0.62 | -0.66 | -0.68 | -0.43 | -0.60 |
| TD181 | -0.71 | -0.68 | -0.75 | -0.26 | -0.62 | -0.72 | -0.65 | -0.69 | -0.43 | -0.61 |
| TRTD32 | -0.70 | -0.77 | -0.76 | -0.29 | -0.65 | -0.75 | -0.63 | -0.67 | -0.40 | -0.63 |
| TD570 | -0.74 | -0.81 | -0.76 | -0.30 | -0.74 | -0.75 | -0.65 | -0.70 | -0.43 | -0.65 |
| TRTD66 | -0.79 | -0.70 | -0.85 | -0.29 | -0.85 | -0.78 | -0.70 | -0.76 | -0.45 | -0.68 |
| TD436 | -0.77 | -0.87 | -0.93 | -0.31 | -0.73 | -0.83 | -0.70 | -0.75 | -0.44 | -0.70 |
| TD292 | -0.78 | -0.90 | -0.91 | -0.31 | -0.66 | -0.78 | -0.75 | -0.80 | -0.45 | -0.70 |
| TD10 | -0.84 | -0.74 | -0.96 | -0.32 | -0.79 | -0.83 | -0.71 | -0.81 | -0.45 | -0.72 |
| TRTD51 | -0.86 | -0.96 | -0.95 | -0.32 | -0.81 | -0.84 | -0.75 | -0.82 | -0.47 | -0.75 |
| **Mean** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | |
| **SD** | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** | |

## Supplementary Figure



Supplementary Figure S1: Phenotyping of shoot angle (A, B, and C) and threshing (D, E, F, and G). Shoot angle means average of angle between effective tillers and soil surface (almost $90^{o}$ (A), around $45^{o}$ (B) and close to $0^{o}$ (C)). Scoring of threshability at a scale of 1 to 4 where 1 = completely free-threshing with virtually all seed released from the hulls (D), 2 = mostly free-threshing with a minor portion of the seed remaining hull (E), 3 = somewhat difficult to thresh with a major portion of the seed remaining hulled (F), and 4 = difficult to thresh with only a few seeds being released from the hulls (G).