**Supplementary Information (SI)**

**Manure fertilizer addition and optimal topdressing nitrogen input improved growth, grain yield and water-nitrogen use efficiencies of winter wheat in the drylands of the Xinjiang Oasis**

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**Supplementary Table S1.** Significance analysis (*F value*) of the interactive effects of manure fertiliser addition, topdressing nitrogen rates, and year on LAI, AGB, *Pn*, *Tr,* NUA and NUEover 2 years.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameter** | **LAI** | **AGB** | ***Pn*** | ***Tr*** | **NUA**  | **NUE** |
| Manure (M) | 242.92\*\* | 106.62\*\* | 0.25ns | 5.58\* | 385.81\*\* | 49.40\*\* |
| N rate (N) | 101.24\*\* | 54.86\*\* | 14.86\*\* | 3.47\* | 200.92\*\* | 171.03\*\* |
| Year (Y) | 1475.17\*\* | 442.73\*\* | 340.87\*\* | 93.95\*\* | 1662.90\*\* | 103.46\*\* |
| M×N | 6.53\*\* | 1.83ns | 2.79ns | 2.71ns | 2.37ns | 15.18\*\* |
| M×N×Y | 7.36\*\* | 1.28ns | 0.05ns | 0.98ns | 0.40ns | 1.39ns |

**Note:** LAI, leaf area index; AGB, aboveground biomass; *Pn*, net photosynthetic rate; *Tr*, transpiration rate; NUA, crop N uptake; NUE, nitrogen use efficiency; \* significant at the 0.05 probability level; \*\* significant at the 0.01 probability level; ns No significant.

**Supplementary Table S2.** Comprehensive principal component scores for different treatments and rankings.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 2021-2022 |  |  |  | 2022-2023 |  |  |
| Treatment | Score | Rank |  | Treatment | Score | Rank |
| M0N0 | -1.33 | 6 |  | M0N0 | -1.08 | 6 |
| M0N150 | 0.3 | 3 |  | M0N150 | 0.03 | 4 |
| M0N300 | 0.16 | 4 |  | M0N300 | -0.25 | 5 |
| M1N0 | -0.58 | 5 |  | M1N0 | 0.14 | 3 |
| M1N150 | 0.92 | 1 |  | M1N150 | 0.77 | 1 |
| M1N300 | 0.54  | 2 |  | M1N300 | 0.40  | 2 |

**Supplementary Table S3.** The averages of the main effects of manure and topdressing nitrogen fertilizers on LAI, aboveground biomass, *Pn* and *Tr*.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Years | Manure (kg ha-1) | Nitrogen fertilizer (kg ha-1) | LAI | ABG(kg ha-1) | *Pn*(µmol·m−2·s−1) | *Tr*(mmol·m−2·s−1) |
| 2021-2022 | M0 | / | 0.64 | 5082.47 | 13.22 | 3.92 |
| M1 | / | 0.81 | 6366.12 | 12.32 | 3.79 |
| / | 0 | 0.55 | 4296.70 | 12.40 | 3.82 |
| / | 150 | 0.82 | 6454.88 | 13.74 | 4.06 |
| / | 300 | 0.81 | 6421.31 | 12.19 | 3.69 |
| 2022-2023 | M0 | / | 1.33 | 8155.48 | 18.36 | 4.90 |
| M1 | / | 1.88 | 10320.33 | 19.54 | 5.74 |
| / | 0 | 1.33 | 8285.67 | 17.25 | 5.24 |
| / | 150 | 1.81 | 10281.53 | 20.38 | 5.65 |
| / | 300 | 1.69 | 9146.52 | 19.30 | 5.07 |

**Note:** LAI, leaf area index; AGB, aboveground biomass; *Pn*, net photosynthetic rate; *Tr*, transpiration rate.

**Supplementary Table S3.** The averages of the main effects of manure and topdressing nitrogen fertilizers on grain yield and components.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Years | Manure (kg ha-1) | Nitrogen fertilizer (kg ha-1) | Spike numbers (×104 ha−1) | Grain number (spike−1) | 1000-grain weight (g) | Grain yield (kg ha−1) |
| 2021-2022 | M0 | / | 180.00 | 37.01 | 29.21 | 1973.97 |
| M1 | / | 209.78 | 38.94 | 29.43 | 2302.91 |
| / | 0 | 160.22 | 39.77 | 30.83 | 1865.99 |
| / | 150 | 218.45 | 36.64 | 28.44 | 2368.24 |
| / | 300 | 206.00 | 37.52 | 28.69 | 2181.09 |
| 2022-2023 | M0 | / | 384.95 | 33.44 | 25.25 | 2788.96 |
| M1 | / | 457.84 | 34.71 | 22.99 | 3045.36 |
| / | 0 | 396.80 | 31.99 | 24.99 | 2784.89 |
| / | 150 | 441.07 | 35.90 | 23.10 | 3031.62 |
| / | 300 | 426.31 | 34.33 | 24.27 | 2934.97 |

**Supplementary Table S3.** The averages of the main effects of manure and topdressing nitrogen fertilizers on NUA, NUE, ETc and WUE.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Years | Manure (kg ha-1) | Nitrogen fertilizer (kg ha-1) | NUA (kg ha−1) | NUE (%) | ETc (mm) | WUE (kg ha−1 mm−1) |
| 2021-2022 | M0 | / | 61.40 | 19.98 | 29.21 | 1973.97 |
| M1 | / | 76.81 | 27.00 | 29.43 | 2302.91 |
| / | 0 | 53.75 | / | 30.83 | 1865.99 |
| / | 150 | 72.49 | 27.17 | 28.44 | 2368.24 |
| / | 300 | 81.09 | 19.81 | 28.69 | 2181.09 |
| 2022-2023 | M0 | / | 104.40 | 29.89 | 25.25 | 2788.96 |
| M1 | / | 140.26 | 35.81 | 22.99 | 3045.36 |
| / | 0 | 101.58 | / | 24.99 | 2784.89 |
| / | 150 | 130.02 | 41.21 | 23.10 | 3031.62 |
| / | 300 | 135.38 | 24.49 | 24.27 | 2934.97 |

**Note:** NUA, crop N uptake; NUE, nitrogen use efficiency; ETc, the actual evapotranspiration; WUE, water use efficiency.