



Supplement of

A first calibration of JULES-crop version 7.4 for rice using the novel O₃-FACE experiment in China

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Table S1**The description of experiments providing the temperature response of photosynthesis rate.**

Exp.	Cultivar	Light intensity ($\mu\text{mol m}^{-2} \text{s}^{-1}$)	CO ₂ concentration ($\mu\text{mol mol}^{-1}$)	Nitrogen use	Stage	References
1	Amaroo	1500	400	High	Tillering	Huang et al. (2021)
2	Shanyou 63					
3	Yannong 19	1500	400	High	Tillering	Yang et al. (2020)
4	Notohikari	1500	380	Low	NA	Yamori et al. (2011)
5				Medium	NA	
6				High	NA	
7	Notohikari	1500	283	NA	21~ 63 days after germination	Nagai and Makino (2009)

1. NA means that the relevant setting was not mentioned in the study.

References

Huang, G., Yang, Y., Zhu, L., Peng, S., and Li, Y.: Temperature responses of photosynthesis and stomatal conductance in rice and wheat plants, *Agric. For. Meteorol.*, 300, 108322, <https://doi.org/10.1016/j.agrformet.2021.108322>, 2021.

Nagai, T. and Makino, A.: Differences Between Rice and Wheat in Temperature Responses of Photosynthesis and Plant Growth, *Plant and Cell Physiology*, 50, 744-755, 10.1093/pcp/pcp029, 2009.

Yamori, W., Nagai, T., and Makino, A.: The rate-limiting step for CO₂ assimilation at different temperatures is influenced by the leaf nitrogen content in several C3 crop species, *Plant, Cell & Environment*, 34, 764-777, <https://doi.org/10.1111/j.1365-3040.2011.02280.x>, 2011.

Yang, Y., Zhang, Q., Huang, G., Peng, S., and Li, Y.: Temperature responses of photosynthesis and leaf hydraulic conductance in rice and wheat, *Plant, Cell & Environment*, 43, 1437-1451, <https://doi.org/10.1111/pce.13743>, 2020.

Supplementary References

Carbon and Nitrogen in Rice Leaves, Stems, and Roots

- Ata-Ul-Karim, S. T., Yao, X., Liu, X., Cao, W., & Zhu, Y. (2014). Determination of critical nitrogen dilution curve based on stem dry matter in rice. *PLoS One*, 9, e104540.
- Chen, G. (2019). Effects of water and nitrogen coupling on growth and yield of rice C langyouhuazhan (Master's thesis, Huazhong Agricultural University) (in Chinese).
- Dongling, J., Wenhui, X., Zhiwei, S., Lijun, L., Junfei, G., Hao, Z., Harrison, M. T., Ke, L., Zhiqin, W., Weilu, W., & Jianchang, Y. (2023). Translocation and distribution of carbon-nitrogen in relation to rice yield and grain quality as affected by high temperature at early panicle initiation stage. *Rice Science*, 30, 598–612.
- Feng, L. (2012). The effect of fertilization on the absorption, partition and accumulation of carbon and nitrogen in rice plants (Master's thesis, Xi'an University of Architecture and Technology) (in Chinese).
- Guo, R. (2006). Changes of soil nitrogen sink and the effects of its changes on nitrogen absorption by rice plant in a long-term fertilized plot (Doctoral dissertation, Nanjing Institute of Soil Science, Chinese Academy of Sciences) (in Chinese).
- He, J., Ma, J., Cao, Q., Wang, X., Yao, X., Cheng, T., Zhu, Y., Cao, W., & Tian, Y. (2022). Development of critical nitrogen dilution curves for different leaf layers within the rice canopy. *European Journal of Agronomy*, 132, 126414.
- Huo, Z., Yang, X., Zhang, H., Ge, M., Ma, Q., Li, M., Dai, Q., Xu, K., Wei, H., Li, G., Zhu, C., Wang, Y., & Yan, X. (2012). Accumulation and translocation of dry matter and nitrogen nutrition in organs of rice cultivars with different productivity levels (in Chinese). *Plant Nutrition and Fertilizer*, 18, 1035–1045.
- Jiang, Q., Zhang, J., Xu, X., Liu, G., & Zhu, J. (2020). Effects of free-air CO₂ enrichment (FACE) and nitrogen supply on N uptake and utilization of indica and japonica rice cultivars. *Ecological Processes*, 9, 35.
- Jiang, Z., Li, X., Zhao, Y., & Li, Y. (2011). N/P absorption and accumulation and N nutrition of hybrid rice (in Chinese). *Fujian Journal of Agricultural Sciences*, 26, 852–859.
- Li, H. X., Bao, A. L., Liang, Z. J., & Cai, H. M. (2016). The effect of glutamine on growth and carbon-nitrogen metabolism in *Oryza sativa* L. cv. Japonica. *Bangladesh Journal of Botany*, 45, 69–74.
- Liang, Z., Bao, A., Li, H., & Cai, H. (2015). The effect of nitrogen level on rice growth, carbon-nitrogen metabolism and gene expression. *Biologia*, 70, 1340–1350.
- Lin, Z., Li, T., Wu, F., Zhang, H., Dai, Q., Ye, S., & Guo, H. (2011). Effects of nitrogen application on yield and C/N of double-cropping rice (in Chinese). *Plant Nutrition and Fertilizer*, 17, 269–275.
- Ma, H., Zhu, J., Xie, Z., Zeng, Q., & Liu, G. (2005). Effects of CO₂ enrichment on the allocation of biomass and C, N uptake in rice organs. *Chinese Journal of Eco-Agriculture*, 13, 38–41.
- Ren, W., Yang, W., Wu, J., Fan, G., & Yang, Z. (2007). Characteristics of nitrogen accumulation and its relationship with root growth of rice after transplanting (in Chinese). *Plant Nutrition and Fertilizer*, 13, 765–771.
- Ruan, X., Shi, F., & Luo, Z. (2011). Effects of nitrogen application on the leaf of C/N and nitrogen uptake and utilization at later developmental stages in different high yield hybrid rice varieties (in Chinese). *Soil Science and Fertilizer*, 17, 35–38.
- Shao, Z., Shen, S., Jia, Y., Mu, H., Wang, Y., Yang, L., & Wang, Y. (2016). Impact of ozone stress on element absorption and distribution of rice genotypes with different ozone sensitivities (in Chinese). *Journal of Agro-Environmental Science*, 35, 1642–1652.
- Wang, H., Zhong, L., Fu, X., Huang, S., Zhao, D., He, H., & Chen, X. (2023). Physiological analysis reveals the mechanism of accelerated growth recovery for rice seedlings by nitrogen application after low-temperature stress. *Frontiers in Plant Science*, 14, 1133592.
- Wang, J., Liu, X., Zhang, X., Li, L., Lam, S. K., & Pan, G. (2019). Changes in plant C, N and P ratios under elevated CO₂ and canopy warming in a rice–winter wheat rotation system. *Scientific Reports*, 9, 5424.

Wei, H., Meng, T., Li, C., Zhang, H., Dai, Q., Ma, R., Wang, X., & Yang, J. (2016). Accumulation, translocation and utilization characteristics of nitrogen in Yongyou 12 yielding over 13.5 t ha⁻¹ (in Chinese). *Acta Agronomica Sinica*, 42, 1363–1373.

Wu, L. (2022). Effects of water and nitrogen interaction on rhizosphere oxygen environment and nitrogen utilization in rice (Master's thesis, Chinese Academy of Agricultural Sciences) (in Chinese).

Xie, Z., Zhu, J., Zhang, Y., Ma, H., Liu, G., Han, Y., Zeng, Q., & Cai, Z. (2002). Responses of rice (*Oryza sativa*) growth and its C, N and P composition to FACE and N, P fertilization. *Acta Ecologica Sinica*, 13, 1223–1230.

Xue, L., Cao, W., Luo, W., Dai, T., & Zhu, Y. (2004). Monitoring leaf nitrogen status in rice with canopy spectral reflectance. *Agronomy Journal*, 96, 135–142.

Xu, X. (2017). Preliminary study on raising rice yield response to elevated carbon dioxide (Master's thesis, University of Chinese Academy of Sciences) (in Chinese).

Ye, Y., Liang, X., Chen, Y., Li, L., Ji, Y., & Zhu, C. (2014). Carbon, nitrogen and phosphorus accumulation and partitioning, and C:N:P stoichiometry in late-season rice under different water and nitrogen managements. *PLoS One*, 9, e101776.

Zhang, L., Pan, G., Zhang, X., Li, L., Zheng, J., Zheng, J., Yu, X., & Wang, J. (2015). Effect of experimental CO₂ enrichment and warming on uptake and distribution of C and N in rice plant (in Chinese). *Soils*, 47, 26–32.

Zhang, W., Yu, J., Xu, Y., Wang, Z., Liu, L., Zhang, H., Gu, J., Zhang, J., & Yang, J. (2021). Alternate wetting and drying irrigation combined with polymer-coated and conventional urea rates increases grain yield, water and nitrogen use efficiencies in rice. *Field Crops Research*, 268, 108165.

Zheng, F., Wang, X., Hou, P., Zhang, W., Lu, F., & Ouyang, Z. (2011). Effects of ozone stress on rice growth and C, N, S element distribution. *Acta Ecologica Sinica*, 31, 1479–1486.

Zhou, D., Zhu, Y., Yang, J., Tian, Y., Yao, X., & Cao, W. (2009). C/N content ratio of rice leaf monitoring based on canopy hyperspectral parameters (in Chinese). *Transactions of the Chinese Society of Agricultural Engineering*, 25, 135–141.

Zhu, D., Song, Y., Huang, H., & Wang, Y. (2017). Effect of water stress in early stage on rice (*Oryza sativa* L.) dry matter accumulation and N uptake and utilization (in Chinese). *Journal of Anhui Agricultural Sciences*, 45, 42–44, 57.

Zhong, X., Agathokleous, E., Wu, J., Zhang, Y., Zhou, Y., Xu, Y., Shang, B., Ji, Y., & Feng, Z. (2025). Elevated ozone mitigates warming-induced methane emissions in a rice paddy field. *Agriculture, Ecosystems & Environment*, 385, 109577.

Zou, C., Qin, D., Gao, J., & Chen, F. (2001). Application technology of N fertilizer on rice i. the index of diagnosing nitrogen nutrition in rice leaf (in Chinese). *Journal of Hunan Agricultural University (Natural Science)*, 27, 29–31.