Creating universal critical nitrogen dilution curves for Japonica rice

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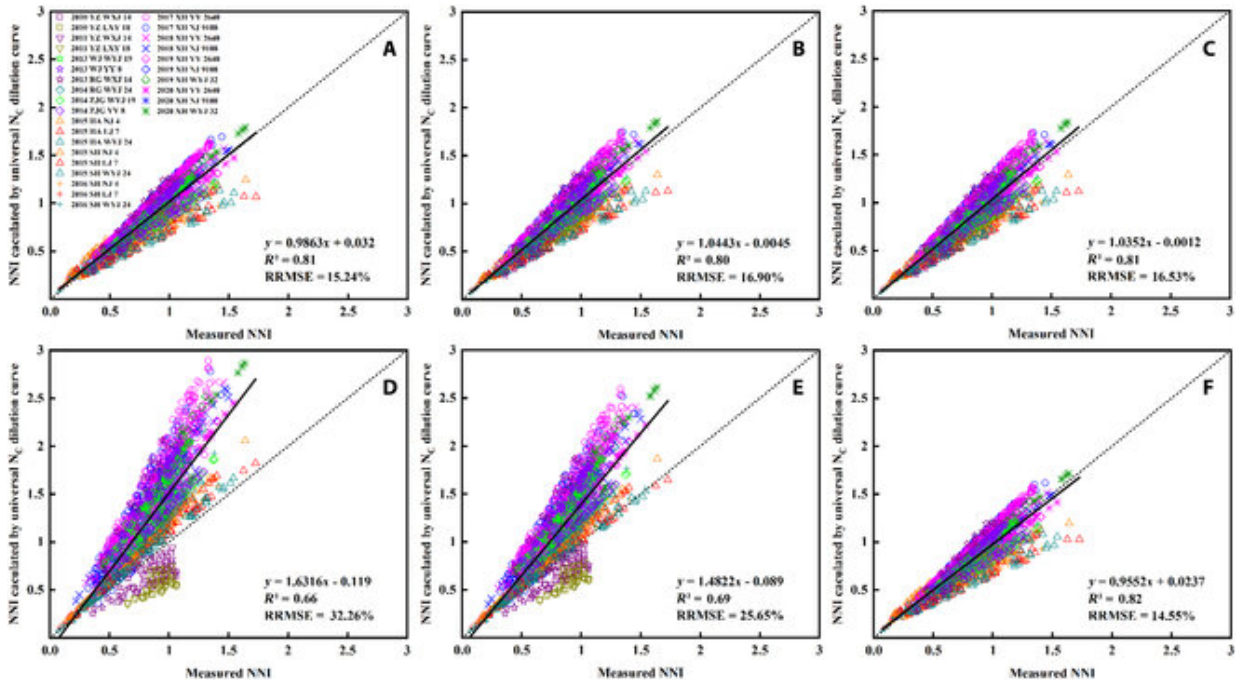

(A), Average (B), RFA (C), Mean (D), Median (E), and MPN (F). The measured NNI values were calculated by each specific NC dilution curve based on the traditional method. Credit: *Plant Phenomics* (2023). DOI: 10.34133/plantphenomics.0036

Rice, a staple crop, is widely cultivated in China. The farmers enhance the rice yield and grain quality through nitrogen (N) fertilizers. But using them in excess negatively affects crop production and harms the

environment. Therefore, determining the optimum quantity of N fertilizers for effective rice growth without any wastage is crucial.

Researchers do so by creating critical N (N_C) dilution curves that relate the N_C concentration of plants to their dry matter weight (DW) or biomass as a power function—$N_C = a \times DW^{-b}$. In this equation, N_C is the minimum N concentration at which the growth rate of DW is maximum, and a and b are parameters that depend on rice cultivars or varieties and environmental conditions.

Researchers traditionally estimated the parameters a and b by sampling and weighing plant measurements, which is laborious and time-consuming. Therefore, machine learning methods are currently employed for this purpose. Some studies have used them to create N_C curves for specific cultivars under particular environments. But a universal N_C curve applicable in a region under various conditions would be more practical.

With this in mind, a group of researchers from China, led by Prof. Xiaojun Liu of Nanjing Agricultural University, has created universal N_C dilution curves for 10 Japonica rice cultivars by conducting 13 N fertilizer-based experiments across 10 years at 7 sites in reaches of the Yangtze river. Their work was published in *Plant Phenomics*.

Prof. Liu briefly explains the research methodology of the present work. "Rice was cultivated using different quantities of N fertilizer in different ratios for various stages of plant growth during each experiment. After that, N_C and DW were measured by a continuous-flow auto-analyzer and micrometer balance, respectively. And the parameters a and b were determined using three approaches—simple data mixing (SDM), random forest algorithm (RFA), and Bayesian hierarchical model (BHM)."

The researchers found that a and b varied with cultivar, year, site, and N

fertilizer quantity and ratio. In particular, while a was highly related to plant height, specific leaf area at the end of tillering, and maximum DW during vegetative growth, b was affected by effective temperature accumulated by the end of tillering, stem-to-leaf DW ratio at the tillering end, and maximum leaf area index during vegetative growth. As a result, different rice growth conditions gave rise to different specific N_C curves.

The researchers averaged the parameters a and b of the specific curves using RFA to create a universal N_C curve. In contrast, while SDM involved fitting all N_C points to a power function, BHM obtained posterior distributions of a and b using the Markov Chain Monte Carlo method. The distributions Most Probable Number (MPN) represented the universal values of the two parameters, respectively. Consequently, two more universal N_C curves, corresponding to SDM and BHM-MPN, were obtained.

Having thus obtained three universal N_C curves, the researchers validated their practicality by comparing their N nutrient index—the ratio of real-time measured N concentration to N_C—to that of corresponding specific curves. "The coefficient of determination was above 0.81 for all three approaches. Thus, all universal N_C curves can accurately determine real-time N concentration and the optimum quantity of N fertilizer. However, RFA and BHM-MPN approaches, compared to SDM, greatly simplify the modeling process and are highly applicable at a regional level," concludes Prof. Liu.

More information: Zhaopeng Fu et al, Potential of Establishing the Universal Critical Nitrogen Dilution Curve for Japonica Rice, *Plant Phenomics* (2023). DOI: 10.34133/plantphenomics.0036

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