

Therefore, for *A. macrocephala*, the most reasonable expectation is that yield can be optimized by a moderate substitution strategy that combines chemical fertilizer with organic fertilizer or bio-organic inputs, rather than by absolute replacement.

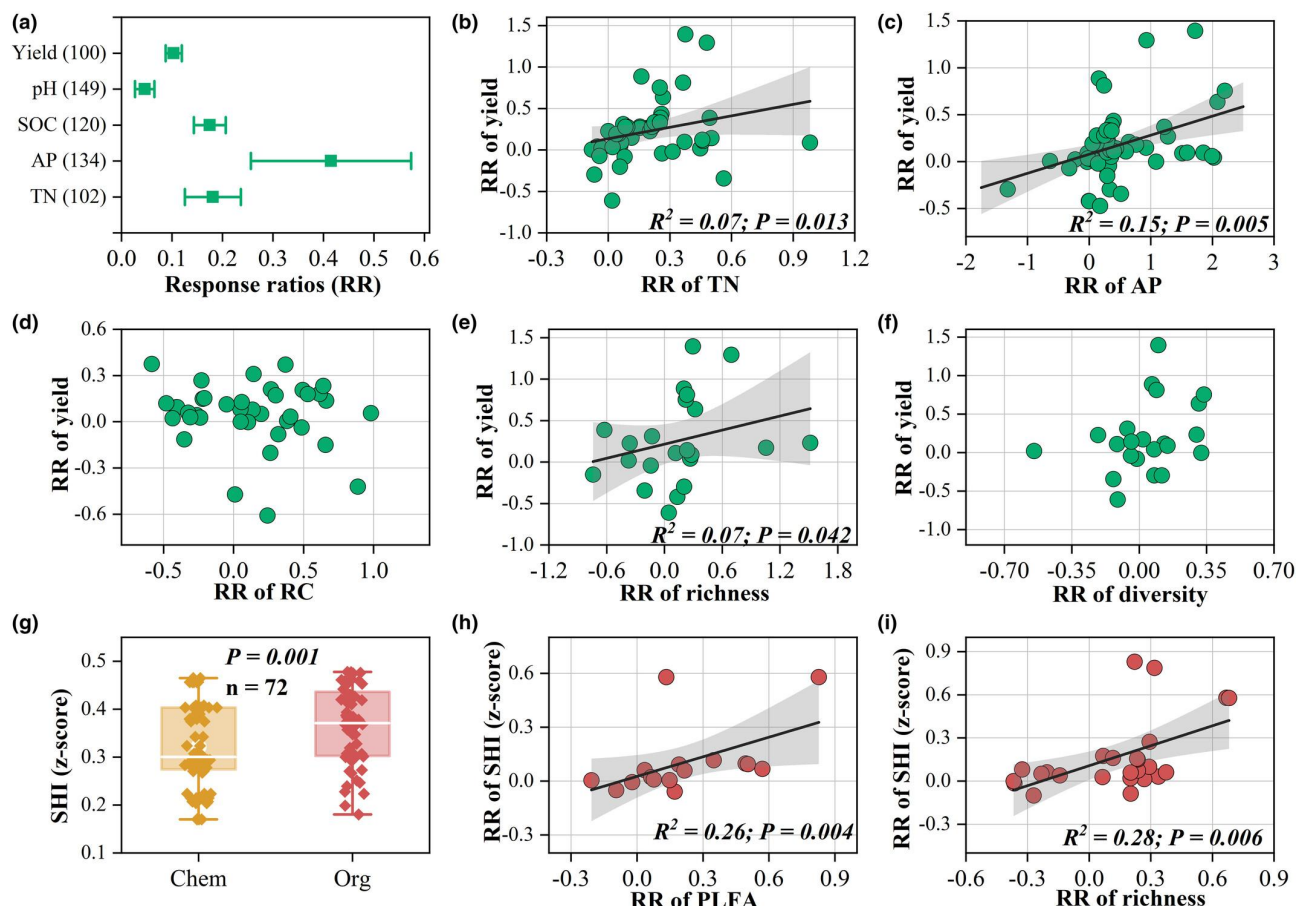


Figure 1 Regulatory factors of the impact of organic fertilizer replacing chemical fertilizer on crop yield and soil health (Adopted from Wang et al., 2025)

Image caption: Effects of organic fertilizers replacing chemical fertilizers on crop yield, soil physicochemical properties (a) and soil health (g). Linear regression analysis between response rate (RR) of total nitrogen (TN) (b), available phosphorus (AP) (c), arbuscular mycorrhizal fungal root colonization (d), richness (e) and diversity (f) and crop yield. Linear regression and analysis between RR of phospholipid fatty acid (PLFA) (h), richness (i) and soil health. Solid points and open points represent significant (95% confidence interval [CI] not overlapping with zero) and non-significant effect sizes, respectively. The numbers in parentheses represent the sample size of observations. The shaded bands with grey colour show 95% pointwise CIs. The soil health index in meta-analysis is calculated by normalizing soil organic carbon, TN, AP and pH values through z-score to obtain the average value. Chem, chemical fertilizer application; Org, organic fertilizer application; PLFA, phospholipid fatty acid; RR, response rate; SHI, soil health index (Adopted from Wang et al., 2025)

4 Mechanisms of Organic Fertilizer Substitution for Chemical Fertilizers in Quality Formation of *Atractylodes macrocephala*

4.1 Effects on accumulation of main active components in *Atractylodes macrocephala*

Organic fertilizer substitution can promote the accumulation of the main active components of *Atractylodes macrocephala*, but the effect is selective and depends on the fertilization mode and the physiological pathway being regulated. In a direct fertilization study on *A. macrocephala*, the HA organic fertilizer treatment produced a significantly higher atractylenolide I content than bacterial filtrate or conventional fertilization, and the highest atractylone-related index also appeared under HA treatment (Kim et al., 2016). This indicates that organic substitution can improve medicinal quality not only through biomass increase but also through enhancement of sesquiterpene lactone accumulation, which is one of the core quality targets in *A. macrocephala* (Lee et al., 2025).