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Statistical Analysis of Yield Components in Wheat under Different Management Practices

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Abstract Wheat yield formation is a complex physiological process jointly regulated by genetic traits, environmental conditions, and agricultural management practices. This study systematically investigates the effects of different management strategies on wheat yield components, including spike number, grains per spike, and thousand-grain weight. By integrating multiple management scenarios such as fertilization intensity, irrigation regimes, and planting density adjustments, the responses of yield formation processes were analyzed in terms of growth dynamics, component interactions, and regional variability. The results indicate that fertilization primarily influences spike development and grain setting, while water availability significantly regulates biomass accumulation and yield stability. Planting density further modulates population structure, leading to trade-offs among yield components. Significant coupling relationships were observed among spike number, grain number, and grain weight, suggesting a coordinated but competitive allocation mechanism. Statistical modeling revealed that management practices exert both direct and indirect effects on final yield through yield component mediation. Moreover, regional analysis highlights that climatic and soil conditions amplify or constrain management effectiveness. The findings provide a comprehensive understanding of how integrated agronomic practices shape wheat yield formation and offer theoretical support for optimizing high-yield and stable production systems under diverse agroecological conditions.

Keywords Wheat yield components; Management practices; Fertilization; Irrigation; Yield modeling

1 Introduction

Wheat is a major source of calories and protein worldwide, and further yield gains are essential to meet rising demand for food and feed. Grain yield in wheat is a complex quantitative trait shaped by genotype, environment, and their interaction, making direct selection on yield alone inefficient. A clearer understanding of yield components and how they respond to management practices is therefore critical for designing agronomic strategies and statistical models that improve both yield level and stability. This paper, "Statistical Analysis of Yield Components in Wheat under Different Management Practices," is positioned within this context. Wheat yield is typically decomposed into spike number per unit area, grain number per spike, and thousand-grain weight, with additional supporting traits such as biological yield and harvest index (Dolijanović et al., 2025). Numerous correlation and path-analysis studies show that grain yield is positively associated with spikes per area, grains per spike, and thousand-grain (or kernel) weight, as well as biological yield and harvest index (Choudhary et al., 2025). Path coefficient analyses repeatedly identify biological yield, grains per spike, and harvest index as having strong direct effects on grain yield, indicating their value as selection or diagnostic traits. Large multi-environment analyses further confirm that grains per unit area, determined by spike number and grains per spike, is the yield component most tightly linked to final yield (Slafer et al., 2022).

Agricultural management practices-especially fertilization, irrigation, tillage, sowing arrangement, and organic amendments-modify resource availability and crop environment, thereby altering yield components rather than yield directly. Meta-analyses and long-term trials show that integrating nitrogen management with irrigation, tillage, and organic inputs can increase wheat yield, nitrogen-use efficiency, and water-use efficiency relative to single-factor optimization. Conventional or well-structured tillage systems often improve grain weight per spike,