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Comparison of Yield Stability among Different Legume Species in Zhejiang

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Abstract Legume crops play an important role in ensuring food security, improving soil fertility, and promoting sustainable agricultural development. However, yield instability caused by climatic fluctuations, environmental stresses, and management variations remains a major challenge for legume production in Zhejiang Province. This study aims to systematically compare the yield stability of different legume crops in Zhejiang by integrating long-term yield data, ecological information, and statistical evaluation methods. The research will analyze yield variation characteristics, stability differences, and environmental adaptability among major legume crops, including soybean, broad bean, pea, mung bean, and common bean. Multiple stability assessment approaches, such as coefficient of variation, AMMI model, GGE biplot analysis, and multivariate statistical methods, will be applied to identify crops with high yield stability and broad ecological adaptability. Furthermore, the physiological, ecological, and genetic mechanisms underlying yield stability will be explored, with emphasis on climate adaptation, resource utilization efficiency, and genotype-environment interactions. A case study of typical ecological regions in Zhejiang will be conducted to reveal regional differences in legume production stability and provide targeted optimization strategies. The findings will contribute to the selection of stable-yielding legume varieties, improvement of precision cultivation practices, and development of climate-resilient legume production systems in Zhejiang Province.

Keywords Legume crops; Yield stability; Genotype-environment interaction; Ecological adaptability; Zhejiang Province

1 Introduction

Legume crops are strategically important to agricultural production, human nutrition, and the ecological transformation of cropping systems in Zhejiang. Legumes provide protein-rich grain and diverse food uses, and many species also contribute to fodder, green manure, and functional food development (Jarecki and Migut, 2022). Their wider value lies not only in seed production but also in their role in sustainable intensification, because legumes fix atmospheric nitrogen through symbiosis, improve soil fertility, reduce synthetic fertilizer demand, and enhance rotational performance of subsequent crops. Meta-analytic and review evidence further shows that legumes support self-sufficiency in plant protein, reduce greenhouse-gas emissions relative to non-legume crops, improve biodiversity and soil health, and fit well with conservation-oriented farming systems. In China, food legumes have long been embedded in rotation, intercropping, and mixed-cropping systems, and the country remains a leading producer of pea, faba bean, mung bean, and adzuki bean. At the same time, China's vast territory and complex ecological conditions create strong spatial heterogeneity in legume adaptation, while changing market conditions have reduced the profitability and planting area of some dry grain legumes, increasing the need to identify species and cultivars with better productivity and stability under local conditions. Zhejiang is characterized by humid subtropical monsoon conditions, diverse micro-environments, and intensive multiple-cropping systems, so production risk is shaped not only by average yield level but by the consistency of yield across years, sites, and management situations. For this reason, evaluating yield stability among legume species is more useful for regional crop and variety recommendation than comparing yield in a single environment alone. This focus is also supported by broader agronomic evidence showing that stable performance across environments is a central target in crop improvement, because yield is a complex quantitative trait jointly controlled by genotype, environment, and their interaction (Islam et al., 2021). A genotype or species is considered practically valuable when it combines relatively high mean yield with low fluctuation across environments, thereby reducing production risk and supporting reliable legume expansion in diversified cropping systems (Baraki et al., 2020).