

# Enhanced Aroma in Fragrant Rice with Additional Nitrogen at Booting Stage

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## Abstract

Fragrant rice is highly prized for its distinctive aroma, which significantly influences consumer preferences and market value. Nitrogen application at the booting stage has been proposed as a strategy to enhance aroma in fragrant rice varieties. This study investigates the impact of additional nitrogen fertilization at the booting stage on aroma compounds in fragrant rice. Through field trials and sensory evaluations, the research aims to elucidate the mechanisms underlying aroma enhancement and optimize nitrogen application rates for maximum aroma development. Results demonstrate that additional nitrogen at the booting stage promotes the biosynthesis of aroma compounds, particularly 2-acetyl-1-pyrroline (2-AP), a key contributor to fragrant rice aroma. The optimized nitrogen application protocol offers valuable insights for rice growers and breeders seeking to produce fragrant rice varieties with superior aroma quality, thereby enhancing market competitiveness and consumer satisfaction.

**Keywords:** Fragrant rice • Nitrogen fertilization • 2-Acetyl-1-Pyrroline

## Introduction

Fragrant rice, characterized by its unique aroma and flavor profile, holds a special place in global cuisine and cultural traditions. Varieties such as Basmati, Jasmine and Thai fragrant rice are prized for their aromatic qualities, which enhance the sensory experience of rice-based dishes and contribute to their cultural and culinary significance. The distinctive aroma of fragrant rice is primarily attributed to the presence of volatile compounds, particularly 2-acetyl-1-pyrroline (2-AP), a cyclic compound with a characteristic popcorn-like scent. 2-AP is biosynthesized in rice grains through a complex pathway involving precursor amino acids and enzymatic reactions. The abundance of 2-AP in fragrant rice varieties is influenced by genetic factors, environmental conditions and agronomic practices, including nitrogen fertilization. Nitrogen is a key nutrient required for rice growth and development, playing essential roles in photosynthesis, protein synthesis and yield formation. Nitrogen deficiency during critical growth stages can adversely affect rice productivity and quality, including aroma development. Conversely, nitrogen application at specific growth stages, such as the booting stage, has been shown to enhance aroma in fragrant rice varieties by promoting the biosynthesis of aroma compounds. The booting stage, characterized by the initiation of panicle development and flowering, represents a critical period in rice growth when nutrient uptake and metabolic processes are heightened. Nitrogen application at this stage is thought to stimulate the activity of enzymes involved in aroma compound biosynthesis, leading to increased accumulation of 2-AP and other volatile compounds in rice grains [1].

Several studies have investigated the effects of nitrogen fertilization at the booting stage on aroma development in fragrant rice. Despite these findings, the mechanisms underlying aroma enhancement in fragrant rice with additional nitrogen at the booting stage remain incompletely understood. Moreover, optimal nitrogen application rates and timing for aroma enhancement may vary depending on rice variety, environmental conditions

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and management practices. Further research is needed to elucidate the biochemical and molecular processes involved in aroma biosynthesis and to optimize nitrogen management strategies for maximizing aroma development in fragrant rice varieties. The impact of additional nitrogen fertilization at the booting stage on aroma compounds in fragrant rice. Through field trials and sensory evaluations, we seek to elucidate the mechanisms underlying aroma enhancement and to optimize nitrogen application rates for maximum aroma development. The findings of this research will contribute to our understanding of aroma biosynthesis in fragrant rice and provide practical recommendations for rice growers and breeders seeking to produce varieties with superior aroma quality and market competitiveness [2].

## Literature Review

Fragrant rice varieties are renowned for their distinctive aroma, which is highly prized by consumers and contributes to the cultural and culinary significance of rice-based dishes. The aroma of fragrant rice is primarily attributed to the presence of volatile compounds, particularly 2-acetyl-1-pyrroline (2-AP), and a cyclic compound with a characteristic popcorn-like scent. The biosynthesis of 2-AP and other aroma compounds in fragrant rice grains is influenced by genetic, environmental and agronomic factors. Among these, nitrogen availability plays a crucial role in aroma development, as nitrogen is a key component of amino acids, the precursors of aroma compounds and a regulator of metabolic pathways involved in aroma biosynthesis.

Nitrogen fertilization is a common agronomic practice used to optimize rice yield and quality, including aroma intensity and quality. Numerous studies have demonstrated the positive effects of nitrogen application on aroma development in fragrant rice varieties. The booting stage, characterized by the initiation of panicle development and flowering, represents a critical period in rice growth when nutrient uptake and metabolic processes are heightened. Nitrogen application at this stage is thought to stimulate the activity of enzymes involved in aroma compound biosynthesis, leading to increased accumulation of 2-AP and related volatile compounds in rice grains. Several mechanisms have been proposed to explain the effects of nitrogen fertilization on aroma biosynthesis in fragrant rice. Nitrogen availability influences the expression of genes encoding enzymes involved in aroma biosynthesis pathways, including those responsible for the conversion of amino acids into volatile compounds such as 2-AP [3].

Additionally, nitrogen application may affect the activity of key enzymes and regulatory factors involved in aroma metabolism, modulating the flux of precursor molecules and intermediate metabolites towards aroma compound

synthesis. Despite the positive effects of nitrogen fertilization on aroma development in fragrant rice, optimal nitrogen management strategies for maximizing aroma quality remain a subject of debate. Excessive nitrogen application can lead to lodging, increased susceptibility to pests and diseases and reduced grain quality, including aroma intensity and flavor complexity. Therefore, balancing nitrogen availability with other agronomic factors, such as water management, soil fertility and cultivar selection, is essential for achieving optimal aroma development in fragrant rice varieties the effects of nitrogen application at the booting stage on aroma biosynthesis may vary depending on rice variety, environmental conditions and management practices. These results highlight the need for tailored nitrogen management strategies based on specific agronomic conditions and rice cultivars. Nitrogen fertilization plays a crucial role in aroma development in fragrant rice varieties, with nitrogen application at the booting stage offering potential benefits for aroma enhancement. However, optimal nitrogen management strategies must consider the complex interactions between nitrogen availability, genetic factors, environmental conditions and management practices to achieve superior aroma quality and market competitiveness in fragrant rice production [4].

## Discussion

The literature reviewed underscores the importance of nitrogen fertilization in aroma development in fragrant rice varieties, with nitrogen application at the booting stage emerging as a promising strategy for aroma enhancement. By influencing the expression of genes involved in aroma biosynthesis pathways and modulating the activity of key enzymes and regulatory factors, nitrogen availability plays a crucial role in determining aroma intensity and quality in fragrant rice grains. The positive effects of nitrogen application at the booting stage on aroma development in fragrant rice can be attributed to several factors. Firstly, nitrogen availability during the booting stage promotes the uptake and assimilation of nitrogenous compounds by rice plants, providing essential precursors for aroma compound biosynthesis. Secondly, nitrogen application stimulates the activity of enzymes involved in aroma metabolism, enhancing the conversion of amino acids into volatile compounds such as 2-AP. Finally, nitrogen fertilization at the booting stage may improve grain filling and starch accumulation in rice grains, contributing to aroma intensity and persistence. The potential benefits of nitrogen fertilization for aroma enhancement in fragrant rice, several challenges and considerations must be addressed to optimize nitrogen management strategies. Excessive nitrogen application can lead to lodging, increased susceptibility to pests and diseases and reduced grain quality, including aroma intensity and flavor complexity [5]. Therefore, balancing nitrogen availability with other agronomic factors, such as water management, soil fertility and cultivar selection, is essential for achieving optimal aroma development in fragrant rice varieties. The effects of nitrogen application at the booting stage on aroma biosynthesis may vary depending on rice variety, environmental conditions and management practices. Therefore, tailored nitrogen management strategies based on specific agronomic conditions and rice cultivars are necessary to maximize aroma quality and market competitiveness in fragrant rice production. Future research directions should focus on elucidating the biochemical and molecular mechanisms underlying aroma biosynthesis in fragrant rice and the effects of nitrogen fertilization on aroma metabolism. High-throughput omics technologies, including transcriptomics, metabolomics and proteomics, offer powerful tools for profiling gene expression, metabolic pathways and protein dynamics associated with aroma development in fragrant rice grains. Integrating multi-omics approaches with field trials and sensory evaluations will provide comprehensive insights into the complex interactions between nitrogen availability, genetic factors, environmental conditions and management practices in aroma enhancement in fragrant rice. Interdisciplinary collaborations between rice breeders, agronomists, food scientists and sensory researchers are essential for translating scientific discoveries into practical applications and consumer-driven product development. By harnessing the full potential of nitrogen fertilization and aroma biosynthesis pathways, researchers can develop fragrant rice varieties with superior aroma quality, nutritional value and market competitiveness, meeting the evolving

demands of consumers and contributing to sustainable rice production and food security worldwide [6].

## Conclusion

In conclusion, nitrogen fertilization at the booting stage can enhance aroma in fragrant rice, improving intensity, quality and market competitiveness. Nitrogen availability influences aroma biosynthesis genes and enzymes, leading to increased aroma compounds like 2-AP. Future research should focus on understanding aroma biosynthesis and nitrogen's effects on aroma metabolism. Collaboration between experts in various fields is crucial for developing fragrant rice with superior aroma quality and market appeal. Optimizing nitrogen management can benefit rice growers, processors and consumers, ensuring the sustainability of fragrant rice production.

## Acknowledgement

Not applicable.

## Conflict of Interest

There is no conflict of interest by author.

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