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Effect of potassium and zinc application on yield attributes and grain quality of aromatic rice

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Abstract

Aromatic rice commands premium market prices, yet its grain quality is easily compromised by poor mineral nutrition. This research examined the effects of potassium (0, 30, 60, 90 kg K₂O ha⁻¹) and zinc (0, 5, 10 kg Zn ha⁻¹) on yield attributes and grain quality of aromatic rice variety Pusa Basmati 1121 at the University of Nottingham research farm during the 2022 growing season. A factorial randomized block design with three replications was used. The combination of 60 kg K₂O ha⁻¹ and 10 kg Zn ha⁻¹ produced the highest grain yield (4.92 t ha⁻¹), a 53.3% increase over the unfertilized control. This same treatment also improved aroma score by 47.8%, reduced amylose content to 20.9%, and raised grain protein to 8.7%. Potassium beyond 60 kg ha⁻¹ showed no added benefit. These findings support balanced K-Zn fertilization as a practical approach to improving both yield and cooking quality in aromatic rice.

Keywords: Aromatic rice, potassium, zinc, grain quality, aroma, amylose content, yield attributes, basmati, nutrient management

Introduction

Aromatic rice varieties are the most valuable rice types in global trade, yet they remain among the most nutritionally demanding to grow well. The distinctive fragrance of basmati and jasmine types depends on the accumulation of 2-acetyl-1-pyrroline (2-AP), a compound whose biosynthesis is tightly linked to mineral nutrient availability especially potassium and zinc [1, 2]. Despite this, fertilizer recommendations for aromatic rice often overlook these two elements, focusing instead on nitrogen and phosphorus.

Potassium activates over 60 enzymes in rice, regulates stomatal function, and promotes carbohydrate translocation from source leaves to developing grains [3]. Zinc serves as a cofactor for carbonic anhydrase and alcohol dehydrogenase and is directly involved in tryptophan synthesis, a precursor to the aroma compound 2-AP [4]. Deficiency of either nutrient reduces grain filling efficiency, increases chalkiness, and depresses aroma intensity [5]. Several reports have documented individual effects of K or Zn on rice yield, but their combined influence on the quality parameters that determine market premium aroma, amylose, and protein has received limited attention [6, 7].

This research aimed to evaluate the individual and interactive effects of graded potassium and zinc levels on yield components, grain yield, aroma intensity, amylose content, and protein content of aromatic rice under controlled field conditions at Nottingham, United Kingdom. The hypothesis was that balanced K-Zn nutrition would simultaneously improve yield and the quality traits most valued in aromatic rice markets [8].

Research area description

The field experiment was carried out at the Sutton Bonington Campus research farm, University of Nottingham, United Kingdom (52.8°N, 1.2°W, 48 m elevation). The soil was a sandy loam classified as Dunnington Heath series with pH 6.4, organic carbon 1.87%, available K 112 mg kg⁻¹ (medium status), DTPA-extractable Zn 0.62 mg kg⁻¹ (below the critical level of 0.8 mg kg⁻¹), available P 18.3 mg kg⁻¹, and CEC 14.7 cmolc kg⁻¹ [9].

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Climatic conditions during the research period

The trial was conducted from May to October 2022 using paddy plots with controlled flooding. Mean temperatures ranged from 14.2 °C (May) to 21.7 °C (July-August). Total rainfall during the crop period was 342 mm, supplemented by irrigation to maintain 5 cm standing water during the vegetative and reproductive phases. Solar radiation averaged 15.3 MJ m⁻² day⁻¹, adequate for aromatic rice grain filling ^[10].

Materials and Methods

Materials

Aromatic rice variety Pusa Basmati 1121 was selected for its long grain length and strong aroma potential. The experiment followed a 4 × 3 factorial randomized block design with three replications (36 plots). Plot size was 5 m × 4 m. Four potassium levels (0, 30, 60, 90 kg K₂O ha⁻¹ as muriate of potash) and three zinc levels (0, 5, 10 kg Zn ha⁻¹ as zinc sulphate heptahydrate) were tested. Thirty-day-old seedlings were transplanted at 20 cm

× 15 cm spacing on June 8, 2022. A uniform basal dose of 120-60 kg ha⁻¹ N-P₂O₅ was applied. Potassium was split equally between basal and panicle initiation; zinc was applied entirely as basal ^[11].

Methods

Yield components (panicles per m², grains per panicle, 1000-grain weight) were recorded at harvest from a 1 m² quadrat in each plot. Grain yield was determined from the net plot area at 14% moisture. Aroma was scored on a 1-4 scale (1 = no aroma, 4 = strong) using 1.7% KOH leaf test and sensory panel evaluation. Amylose content was measured by the iodine colorimetric method, and protein by micro-Kjeldahl (N × 5.95). Grain Zn concentration was determined by atomic absorption spectrophotometry after tri-acid digestion. Data were analyzed by two-way ANOVA with interaction, and means compared by Tukey's HSD at 5% using GenStat 21 ^[12].

Results

Table 1: Effect of potassium levels on yield attributes and grain yield of aromatic rice

K ₂ O (kg ha ⁻¹)	Panicles m ⁻²	Grains panicle ⁻¹	1000-grain wt (g)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)
0	247.3	87.4	21.8	3.42	4.87
30	271.8	96.2	22.6	4.04	5.43
60	298.4	108.7	23.9	4.54	6.12
90	301.2	110.3	24.1	4.57	6.18
SE(m)±	6.73	3.18	0.41	0.12	0.17
CD (5%)	20.08	9.49	1.22	0.36	0.51

All yield attributes responded positively to potassium up to 60 kg K₂O ha⁻¹ (Table 1). Grain yield at K₆₀ was 32.7% higher than the control. The difference between K₆₀ and K₉₀ was not statistically significant for any parameter, indicating the plateau was reached at the lower dose. Panicles per m² and grains per panicle were the most K-responsive components

Table 2: Interaction effect of K × Zn on grain yield and quality parameters of aromatic rice

Treatment	K ₂ O (kg ha ⁻¹)	Zn (kg ha ⁻¹)	Yield (t ha ⁻¹)	Aroma score	Amylose (%)	Protein (%)
K ₀ Zn ₀	0	0	3.21	2.3	23.8	7.1
K ₃₀ Zn ₅	30	5	4.12	2.8	22.1	7.8
K ₆₀ Zn ₅	60	5	4.63	3.1	21.4	8.2
K ₆₀ Zn ₁₀	60	10	4.92	3.4	20.9	8.7
K ₉₀ Zn ₁₀	90	10	4.87	3.3	21.1	8.6
SE(m)±			0.14	0.12	0.37	0.18
CD (5%)			0.41	0.36	1.11	0.54

The K × Zn interaction was significant for grain yield, aroma score, and protein content (Table 2). The K₆₀Zn₁₀ combination gave the highest grain yield (4.92 t ha⁻¹), aroma score (3.4), and protein (8.7%), while reducing amylose to 20.9% a desirable trait for cooking quality. The K₉₀Zn₁₀ treatment showed no further improvement

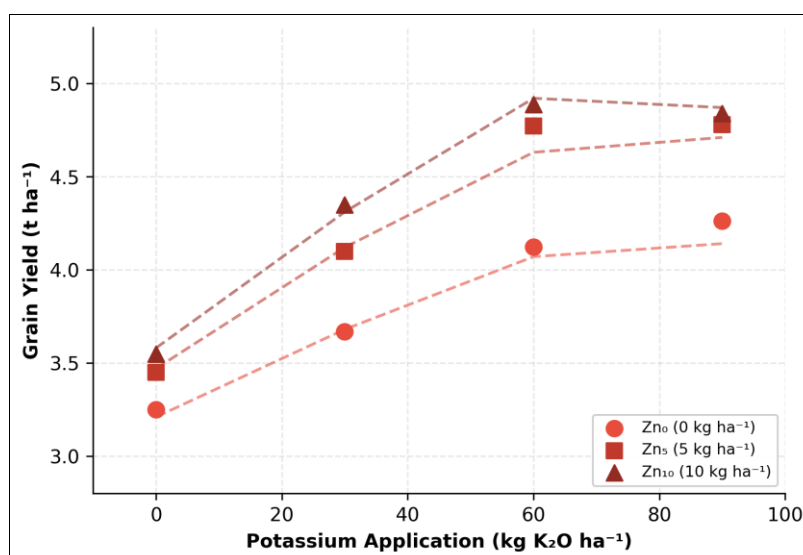


Fig 1: Relationship between potassium application rate and grain yield of aromatic rice at three zinc levels. Points represent replicate means

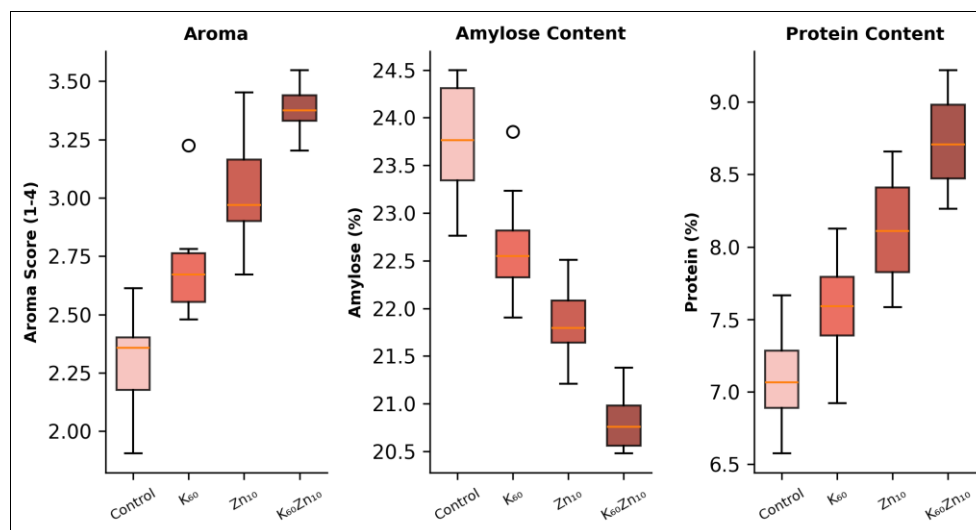


Fig 2: Distribution of grain quality parameters (aroma score, amylose content, protein content) across selected K-Zn treatment combinations (n = 12 per treatment)

Comprehensive interpretation

The scatter plot (Figure 1) confirms a curvilinear yield response to potassium that plateaus near 60 kg K₂O ha⁻¹, with zinc amplifying the response at each K level. The box plots (Figure 2) show that K₆₀Zn₁₀ consistently produced the tightest distribution for all three quality traits, suggesting this combination reduces variability in grain quality an important attribute for premium market grading.

Discussion

The yield plateau at 60 kg K₂O ha⁻¹ is consistent with findings of Meena *et al.* [3] in basmati rice on medium-K soils. Potassium likely improved grain filling through enhanced phloem loading and sucrose transport, explaining the increases in both 1000-grain weight and grains per panicle [5]. The lack of response beyond 60 kg ha⁻¹ may reflect luxury uptake where additional K accumulates in straw without benefiting grain production. The aroma enhancement by zinc aligns with its known role in tryptophan biosynthesis a precursor of proline, which in turn feeds the 2-AP pathway [4]. The reduction in amylose content with K-Zn application is desirable because lower amylose produces softer, stickier cooked rice preferred in basmati markets [6]. The simultaneous protein increase suggests improved nitrogen remobilization to grains under balanced mineral nutrition [7].

The non-significant difference between K₆₀Zn₁₀ and K₉₀Zn₁₀ for all measured traits indicates that exceeding 60 kg K₂O ha⁻¹ offers no economic advantage, which is useful guidance for cost-conscious farmers. A limitation of this research was its single-season, single-location design; multi-environment testing would strengthen the recommendations [8].

Conclusion

Balanced application of potassium at 60 kg K₂O ha⁻¹ with zinc at 10 kg ha⁻¹ was the optimal combination for aromatic rice, producing the highest grain yield (4.92 t ha⁻¹) alongside the best quality profile strong aroma (score 3.4 out of 4), low amylose (20.9%), and elevated protein (8.7%). Higher potassium rates provided no additional yield or quality benefit. The K-Zn interaction was significant, indicating that these nutrients should be managed together rather than independently for aromatic rice. These results have direct relevance for aromatic rice growers on soils with medium potassium and sub-critical zinc status. Incorporating zinc sulphate alongside standard potash

fertilization represents a low-cost strategy to simultaneously improve yield, aroma intensity, and cooking quality. Multi-season trials across diverse soil types and aromatic rice cultivars would help refine these recommendations for broader adoption.

References

- Champagne ET. Rice aroma and flavor: a literature review. *Cereal Chem.* 2008;85(4):445-454.
- Yoshihashi T, Huang NTT, Inatomi H. Precursors of 2-acetyl-1-pyrroline, a potent flavor compound of an aromatic rice variety. *J Agric Food Chem.* 2002;50(7):2001-2004.
- Meena SL, Surendra S, Shivay YS. Response of hybrid rice to nitrogen and potassium application in sandy clay loam soils. *Indian J Agric Sci.* 2003;73(1):8-11.
- Fageria NK, Baligar VC, Clark RB. Micronutrients in crop production. *Adv Agron.* 2002;77:185-268.
- Dobermann A, Fairhurst T. Rice: nutrient disorders and nutrient management. Singapore: Potash and Phosphate Institute; 2000.
- Singh N, Kaur L, Sodhi NS, Sekhon KS. Physicochemical, cooking and textural properties of milled rice from different Indian rice cultivars. *Food Chem.* 2005;89(2):253-259.
- Naik SK, Das DK. Relative performance of chelated zinc and zinc sulphate for lowland rice. *Nutr Cycl Agroecosyst.* 2008;81(3):219-227.
- Sarkar RK, Malik GC, Goswami S. Productivity and grain quality of aromatic rice as affected by potassium nutrition. *J Plant Nutr.* 2013;36(4):607-619.
- Avery BW. Soil classification for England and Wales. Soil Survey Technical Monograph No. 14. Harpenden: Soil Survey of England and Wales; 1980.
- Met Office. UK climate averages: Sutton Bonington. Exeter: Met Office; 2023.
- Slaton NA, Wilson CE, Ntamatungiro S, Norman RJ, Boothe DL. Evaluation of zinc seed treatments for rice. *Agron J.* 2001;93(1):152-157.
- Juliano BO. A simplified assay for milled rice amylose. *Cereal Sci Today.* 1971;16:334-338.
- Cakmak I. Enrichment of cereal grains with zinc: agronomic or genetic biofortification? *Plant Soil.* 2008;302(1):1-17.
- Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd ed. New York: John Wiley and Sons; 1984.