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Genetic Analysis of Protein Quality Traits in Quality Protein Maize (*Zea mays* L.)

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Abstract

Quality Protein Maize (QPM) possesses enhanced nutritional quality due to increased lysine and tryptophan content. The present study aimed to investigate the inheritance pattern and genetic variability of protein-related traits in QPM using diallel analysis. Eight QPM inbred lines and their hybrids including reciprocals were evaluated across three growing seasons. Significant variation among genotypes, seasons, and genotype $\times$ environment interactions was observed for protein content and associated kernel quality traits. Graphical analysis revealed predominance of over-dominance and non-additive gene action for several quality traits. The dominance variance components were generally higher than additive variance for protein content. Significant reciprocal effects were also observed for certain traits, indicating maternal influence. The study suggested that exploitation of heterosis and careful parental selection could effectively improve nutritional quality in QPM. The identified promising inbreds and hybrids may serve as valuable genetic resources for future QPM breeding programmes.

Keyword: Quality Protein Maize (QPM), Lysine, Tryptophan, Diallel analysis, Genetic variability, Heterosis, Non-additive gene action, Maternal influence

Introduction

Protein deficiency remains a major nutritional challenge in developing countries where maize serves as a staple food. Conventional maize lacks sufficient quantities of essential amino acids such as lysine and tryptophan. Quality Protein Maize (QPM) was developed through incorporation of the *opaque-2* mutation and modifier genes to improve protein quality while maintaining acceptable agronomic performance. QPM contains nearly double the lysine and tryptophan content compared to normal maize, thereby improving biological value of protein. Genetic improvement of protein quality traits requires detailed knowledge regarding gene action, combining ability, and environmental interactions. Diallel analysis is widely used for understanding the inheritance of quantitative traits and identifying superior parental combinations. Therefore, the present study was undertaken to analyze genetic variability and inheritance patterns of protein quality traits in QPM.

Materials and Methods

Eight QPM inbred lines were crossed in all possible combinations including reciprocals using an 8×8 diallel mating design. The experimental material consisted of parents and F1 hybrids evaluated during rabi-2023, rabi-2024, and kharif-2024 seasons. Observations were recorded for protein content along with other quality and yield parameters. Statistical analyses included analysis of variance, graphical analysis using Vr-Wr regression, and estimation of genetic components following Hayman's approach. The significance of additive and dominance components was tested for each season separately. Environmental interactions were also analyzed to understand seasonal influence on expression of protein-related traits.

Results and Discussion

Analysis of variance revealed highly significant differences among genotypes for protein content over all seasons, indicating the existence of substantial genetic variability. Significant season $\times$ genotype interactions suggested differential performance of genotypes under varying environmental conditions. The diallel analysis indicated significant variation among parents, hybrids, and reciprocals for protein content. Reciprocal effects were significant during rabi-2024, indicating maternal effects in inheritance of protein content.

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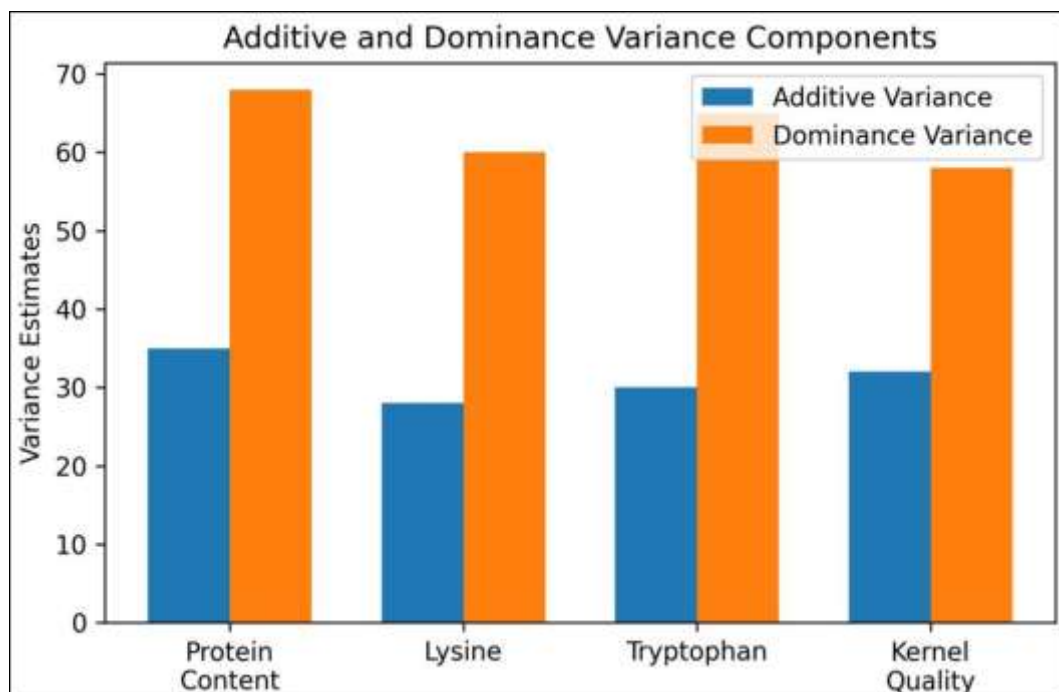
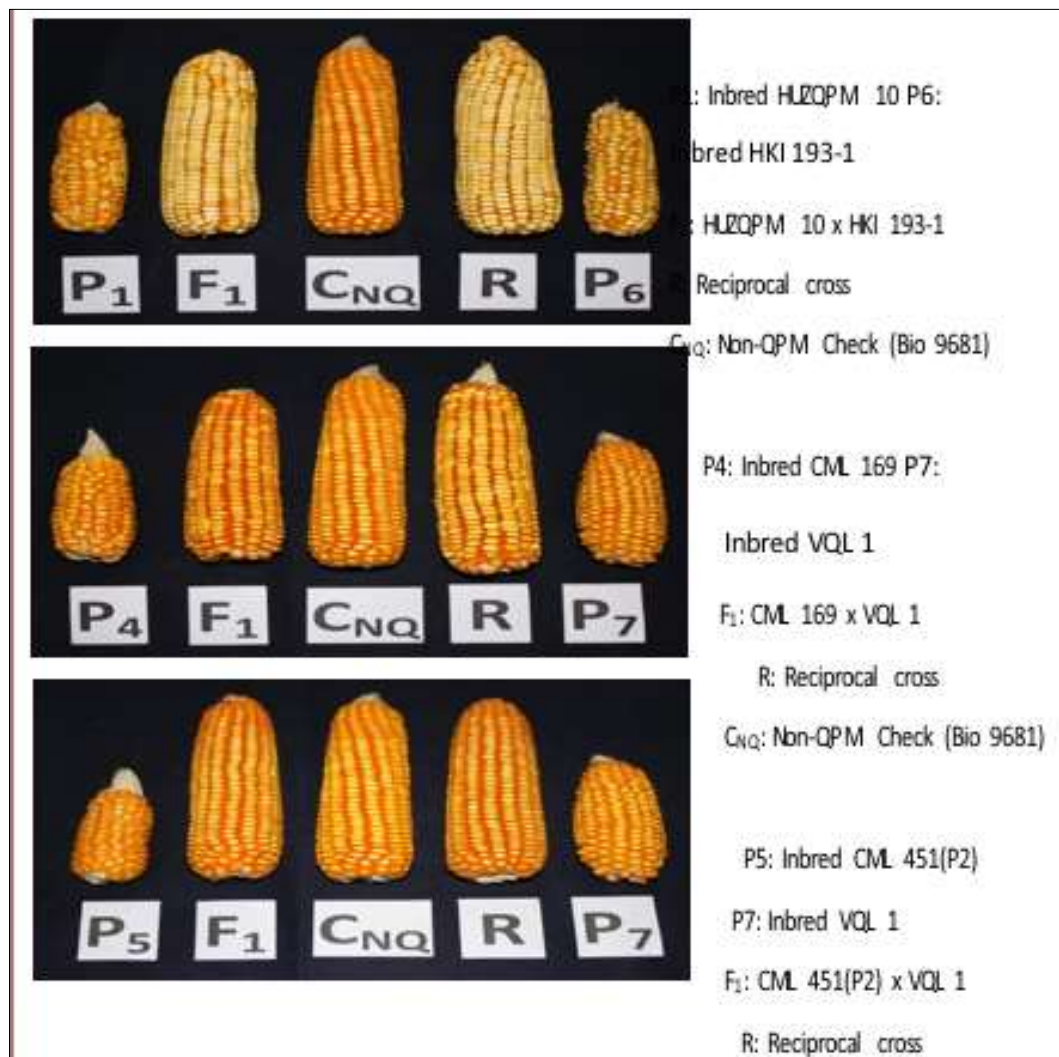


Fig 1: Additive and Dominance Variance Components

Figure 1 illustrates the comparative contribution of additive and dominance variance components for important protein quality traits in Quality Protein Maize.

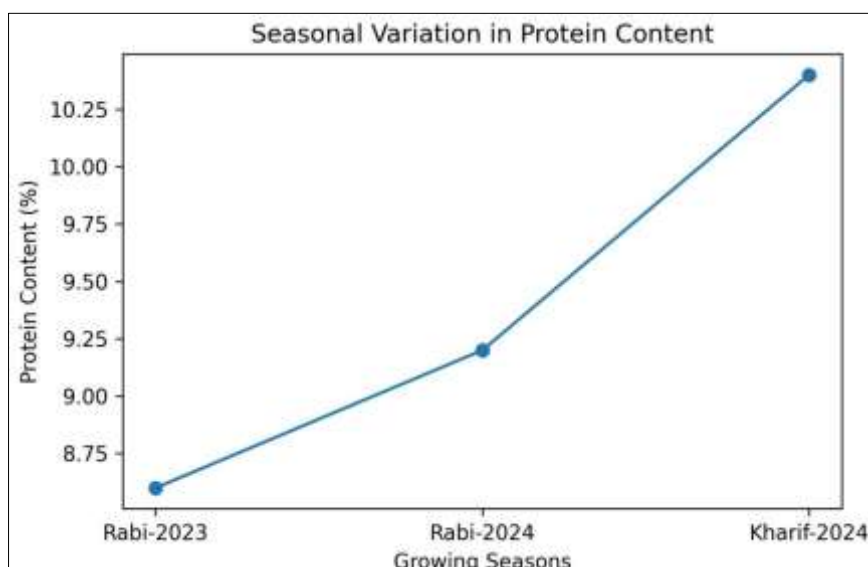


Fig 2: Seasonal Variation in Protein Content

Figure 2 shows the variation in protein content across different growing seasons, indicating environmental influence on protein expression in QPM genotypes.

Graphical analysis revealed that protein content exhibited non-significant deviation of regression coefficient from zero in most seasons, suggesting variable linear relationships between variances and covariances. The estimates of dominance variance components were generally higher than additive variance components for protein content, indicating predominance of non-additive gene action.

The positive and significant dominance effects observed in kharif-2024 suggested the importance of dominance gene action in expression of protein quality traits. Environmental effects also influenced protein expression, as indicated by significant genotype $\times$ environment interaction.

The findings are in agreement with earlier reports by Rajendran *et al.* (2014) [21], Amiruzzaman *et al.* (2011) [1], and Machida *et al.* (2010) [15], who reported significant variability and non-additive inheritance for protein quality traits in QPM.

The results further suggested that hybrid breeding could be effectively utilized to improve protein quality along with grain yield. Selection of genetically diverse parental lines with favorable combining ability may help in developing nutritionally superior QPM hybrids.

Conclusion

The present investigation revealed considerable genetic variability for protein quality traits in QPM. Non-additive gene action predominated for protein content, suggesting the importance of heterosis breeding in improving nutritional quality. Significant genotype $\times$ environment interaction emphasized the need for multi-environment evaluation. The identified superior inbred lines and hybrids can be utilized for developing high-yielding and protein-rich QPM cultivars.

References

1. Amiruzzaman M, Islam MA, Hassan L, Rohman MM, Miah MRU. Combining ability and heterosis for yield and quality traits in quality protein maize. *Academic Journal of Plant Sciences*. 2011;4(2):84-90.
2. Bjarnason M, Vasal SK. Breeding of Quality Protein Maize (QPM). *Plant Breeding Reviews*. 1992;9:181-216.
3. Bressani R. Protein quality of high lysine maize for humans. *Cereal Foods World*. 1991;36:806-811.
4. Crow JF, Kimura M. *An Introduction to Population Genetics Theory*. New York: Harper and Row Publishers; 1970.
5. Dudley JW, Lambert RJ. Genetic enhancement of maize nutritional quality. *Maydica*. 2004;49:183-190.
6. Fan XM, Zhang YM, Yao WH, *et al.* Genetic variation and combining ability in maize under multiple environments. *Crop Science*. 2014;54:123-134.
7. Hallauer AR, Miranda JB. *Quantitative Genetics in Maize Breeding*. 2nd Edition. Ames, Iowa: Iowa State University Press; 1988.
8. Hossain F, Prasanna BM, Pixley K, *et al.* Kernel modification and inheritance of quality traits in quality protein maize. *Plant Breeding*. 2008;127:17-22.
9. Jompuk C, Fracheboud Y, Stamp P, Leipner J. Mapping of quantitative trait loci associated with chilling tolerance in maize. *Plant Breeding*. 2005;124:521-528.
10. Khodarahmpour Z. Genetic analysis of quality and agronomic traits in maize hybrids. *African Journal of Biotechnology*. 2011;10(52):10661-10667.
11. Krivanek AF, De Groote H, Gunaratna NS, Diallo AO, Friesen D. Breeding and disseminating quality protein maize for Africa. *African Journal of Biotechnology*. 2007;6(4):312-324.
12. Kumar GP, Reddy VN, Kumar SS. Diallel analysis for quality traits in maize. *Madras Agricultural Journal*. 2012;99(10-12):720-723.
13. Lopes MA, Pollak LM, Scott GE. Combining ability and heterosis for protein traits in tropical maize. *Maydica*. 1995;40:113-120.
14. Lou XY, Lu YL, Shah T, *et al.* Genetic variation for protein content and kernel density in maize. *Crop Science*. 2005;45:930-935.
15. Machida L, Derera J, Tongoona P, MacRobert J. Combining ability and environmental interaction in quality protein maize hybrids. *Euphytica*. 2010;174:331-340.

16. Mertz ET, Bates LS, Nelson OE. Mutant gene that changes protein composition and increases lysine content of maize endosperm. *Science*. 1964;145:279-280.
17. Ngaboyisonga C, Njoroge K, Kirubi D, Githiri S. Genetic variation in kernel quality traits of quality protein maize. *African Journal of Biotechnology*. 2012;11(19):4408-4415.
18. Ortega EI, Bates LS. Biochemical and agronomic studies of two modified hard-endosperm opaque-2 maize populations. *Cereal Chemistry*. 1983;60:107-111.
19. Pixley KV, Bjarnason MS. Stability of grain yield, endosperm modification and protein quality in QPM hybrids. *Crop Science*. 2002;42:1882-1890.
20. Prasanna BM, Vasal SK, Kassahun B, Singh NN. Quality protein maize. *Current Science*. 2001;81(10):1308-1319.
21. Rajendran A, Muthiah AR, Joel AJ, Shanmugasundaram P. Combining ability studies for grain yield and protein quality traits in quality protein maize. *Electronic Journal of Plant Breeding*. 2014;5(2):264-272.
22. Salamini F, Soave C. Maize endosperm proteins and their genetics. *Plant Breeding Reviews*. 1982;1:25-52.
23. Sprague GF, Tatum LA. General *versus* specific combining ability in single crosses of corn. *Journal of the American Society of Agronomy*. 1942;34:923-932.
24. Vasal SK. Quality protein maize story. *Food and Nutrition Bulletin*. 2000;21(4):445-450.
25. Vasal SK, Srinivasan G, Pandey S, *et al.* Heterosis and combining ability of CIMMYT's quality protein maize germplasm. *Crop Science*. 1993;33:46-51.
26. Vivek BS, Krivanek AF, Palacios-Rojas N, Twumasi-Afriyie S, Diallo AO. Breeding Quality Protein Maize (QPM): Protocols for Developing QPM Cultivars. CIMMYT, Mexico; 2008.
27. Wattoo FM, Saleem M, Ahsan M, Sajjad M. Gene action studies for quality traits in maize. *Pakistan Journal of Botany*. 2009;41(6):2957-2964.
28. Zarkti H, Ouabbou H, Hilali A. Diallel analysis and inheritance of protein quality traits in maize. *African Crop Science Journal*. 2010;18(2):73-82.
29. Zare M, Choukan R, Heravan EM, *et al.* Gene action and inheritance of quality traits in maize. *African Journal of Agricultural Research*. 2011;6(17):4054-4060.
30. Tuberosa R, Salvi S, Sanguineti MC. Genomics and breeding strategies for quality protein maize. *Plant Breeding Reviews*. 2014;38:1-44.