RESEARCH PAPER

Productivity and profitability of quality protein maize hybrids under graded fertility levels in coastal Andhra Pradesh

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Abstract: Field study was conducted during *rabi,* 2023–24 to evaluate the performance of quality protein maize (QPM) hybrids under graded fertility regimes. The trial was laid out in a split-plot design with three fertility levels in the main plots {100%, 125% and 150% of recommended dose of fertilizers (RDF)} and four QPM hybrids (APQH 1, APQH 5, HQPM 1 and HQPM 5) in the sub-plots. Increasing fertilizer dose to 150% RDF (360:120:120 kg N:P_2O_5:K_2O/ha) significantly improved growth and yield parameters, resulting in higher grain yield (8535 kg/ha), which was 18.5% higher over 100% RDF, along with increased net returns (Rs. 1,08,727/ha), representing a 28% gain over 100% RDF (Rs. 85,026/ha), with a B:C ratio of 2.56. Among the tested hybrids, HQPM 1 outperformed the others by registering the highest grain yield (9110 kg/ha), stover yield (10453 kg/ha) and economic returns (Rs. 1,22,805/ha net returns with a B:C ratio of 2.81). Hence, cultivation of the QPM hybrid HQPM 1 with 150% RDF is advisable for attaining greater productivity and profitability during the *rabi* season in coastal Andhra Pradesh.

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Introduction

Maize (*Zea mays* L.) is an important cereal crop cultivated worldwide for food, feed and industrial purposes. However, the protein of conventional maize is deficient in essential amino acids such as lysine and tryptophan, which limits its nutritional quality. The development of Quality Protein Maize (QPM) through incorporation of the opaque-2 gene complex along with modifier genes represented a major advancement in improving the biological value of maize protein (Prasanna *et al*., 2001; Sofi *et al*., 2009). QPM contains nearly double the lysine and tryptophan content compared to normal maize, resulting in improved protein quality and digestibility (Bressani, 1992). Recent reviews further emphasize the nutritional and bioactive advantages of QPM and its potential role in enhancing dietary protein security (Adeoluwa *et al*., 2022).

Considerable genetic variability exists among QPM inbreds and hybrids, leading to differences in yield potential and adaptation across environments. Multi-environment evaluations have demonstrated significant variation in grain yield expression of QPM hybrids across locations, highlighting the importance of region-specific assessment (Kumar *et al*., 2005). In addition, studies on yield attributes have indicated that genotypic differences influence cob characteristics and grain productivity under varying management conditions (Jaliya *et al*., 2008; Jena *et al*., 2015; Laghari *et al.,* 2024). Such variability necessitates systematic evaluation of QPM hybrids under defined agro-climatic situations.

Nutrient management is a key factor governing maize productivity. Being a nutrient-exhaustive crop, maize responds markedly to balanced application of nitrogen (N), phosphorus (P) and potassium (K). Integrated and graded nutrient management strategies have been shown to significantly influence growth, yield attributes and grain quality in QPM (Kashyap *et al*., 2024). Earlier studies in maize have consistently reported that incremental and balanced NPK fertilization enhances vegetative growth, yield components and final grain yield (Adediran and Banjoko, 1995; Asghar *et al*., 2010; Khan *et al*., 2011). Higher fertility regimes have also been associated with improvement in kernel number and test weight in maize (Singh *et al*., 2003). However, hybrid response to enhanced fertility depends on genetic constitution and environmental conditions (Adhikari *et al*., 2021; Adeoluwa *et al*., 2022), underscoring the need to identify suitable genotypes for specific fertility regimes.

In coastal Andhra Pradesh, maize cultivation during the *rabi* season is expanding under irrigated conditions. The *rabi* environment differs from the *kharif* season in terms of temperature regime, radiation pattern and moisture dynamics, which can influence nutrient uptake, dry matter accumulation and yield formation. Although substantial research exists on nutrient management in maize, systematic evaluation of QPM hybrids under graded fertility levels during the *rabi* season in the Godavari agro-climatic zone remains limited. Moreover, economic assessment is essential to ensure that enhanced fertilizer inputs translate into improved profitability (Kumar *et al*., 2005).

Therefore, the present study was undertaken to evaluate the effect of different fertility levels on growth, yield attributes, productivity and profitability of QPM hybrids during *rabi*, 2023–24 under Andhra Pradesh conditions.

Materials and methods

The field experiment was conducted during *rabi,* 2023–24 at the Agricultural Research Station (ARS), Peddapuram, Andhra Pradesh, India (17.08° N latitude, 82.13° E longitude, 35 m above mean sea level). The experimental field had sandy loam soil, nearly neutral in reaction (pH 6.92), with electrical conductivity of 0.12 dS/m and organic carbon content of 0.47%. The available nutrient status was low in N (220 kg N/ha) and K (116 kg K_2O/ha) and medium in P (35 kg P_2O_5/ha). The experiment was conducted in a split-plot design with three replications. The main plots were assigned to different fertility levels, while the sub-plots consisted of four QPM hybrids. The fertility treatments included three levels of NPK: 100% (240:80:80 kg N:P_2O_5:K_2O/ha), 125% (300:100:100 kg N:P_2O_5:K_2O/ha) and 150% of recommended dose of fertilizers (RDF) (360:120:120 kg N:P_2O_5:K_2O/ha). The sub-plots were allotted to four QPM hybrids: APQH 1, APQH 5, HQPM 1 and HQPM 5. Crop management practices were followed according to ANGRAU recommendations to ensure optimal crop growth and yield. Nitrogen was applied in four splits (basal, 20–25, 40–45 and 60–65 DAS), P was given entirely as basal and K was applied in two splits (basal and at flowering) as per the treatment schedule. Five plants were randomly selected and tagged in each plot for recording growth parameters, yield attributes and phenological observations. Grain and stover yields from net plot area were converted to per hectare basis. Economic returns were calculated based on prevailing market prices of produce and cost of cultivation. Returns per rupee invested were worked out by computing benefit–cost ratio. The data on various characters studied during the investigation were statistically analyzed in a split-plot design as per the procedure described by Gomez and Gomez (1984). The treatment differences were tested using the critical difference at 5 per cent level of significance.

Results and discussion

Growth and phenological parameters

Fertility levels significantly influenced plant height and phenological development of QPM (Table 1). Plant height increased progressively with increasing fertility. Application of 150% RDF significantly increased the plant height (196.4 cm) compared to 100% RDF (180.3 cm), indicating improved vegetative growth under enhanced nutrient supply. However, this treatment was found to be on par with 125 % RDF (190.6 cm). Increased plant height under higher NPK levels may be attributed to improved nutrient availability promoting cell division and dry matter accumulation. Similar findings were reported by Asghar *et al.* (2010) and Gul *et al*. (2015).

Days taken to 50% tasselling and silking were reduced with increasing fertility levels. Application of 150% and

Table 1. Growth and phenology of QPM hybrids as affected by varying fertility levels

Treatments	Plant height (cm)	Plants ('000/ha)	Days to 50% tasselling	Days to 50% silking
Main plot: Fertility level				
100 % RDF	180.3	69.8	55.4	57.7
125 % RDF	190.6	70.4	54.8	57.2
150 % RDF	196.4	69.7	53.0	55.6
SEm ±	0.96	1.14	0.12	0.17
CD (p = 0.05)	3.10	NS	0.46	0.68
CV (%)	3.4	5.7	0.7	1.0
Sub - plot: QPM hybrid				
APQH 1	194.1	77.4	52.3	54.6
APQH 5	175.1	74.8	55.3	57.7
HQPM 1	188.2	81.1	55.8	58.5
HQPM 5	170.7	46.7	54.1	56.5
SEm ±	2.14	1.81	0.13	0.19
CD (p = 0.05)	6.40	5.37	0.38	0.56
CV (%)	4.0	7.7	0.7	0.9
Interaction	NS	NS	NS	NS

125% RDF recorded earlier tasselling (53.0 and 54.8 days) and silking (55.6 and 57.2 days) compared to 100% RDF (55.4 and 57.7 days, respectively). Adequate nutrient supply accelerates metabolic activities and promotes earlier reproductive transition, as also observed by Singh *et al.* (2003); Adhikari *et al*. (2021).

Among hybrids, significant variation was observed in plant height and phenological parameters. APQH 1 and HQPM 1 recorded greater plant height (194.1 cm and 188.2 cm, respectively), while HQPM 5 recorded comparatively lower values (170.7 cm). Variation was also observed in days to 50% tasselling and silking, with APQH 1 recording earlier tasselling (52.3 days) and silking (54.6 days), whereas HQPM 1 recorded relatively delayed tasselling (55.8 days) and silking (58.5 days). Such differences in phenological behaviour among hybrids may be attributed to genetic variability influencing growth duration and reproductive development under varying fertility conditions (Adhikari *et al.,* 2021). Interaction effects were non-significant.

Yield attributes

Yield attributes responded positively to increasing fertility levels (Table 2). Cob length and cob girth increased from 17.8 and 15.8 cm under 100% RDF to 18.8 and 16.3 cm under 150% RDF and were on par with 125% RDF (18.3 and 16.0 cm, respectively). Similarly, number of kernels per row increased from 36.0 to 42.1, while 100-seed weight improved from 27.4 g to 30.3 g. Enhanced nutrient availability improves assimilate production and grain filling. Similar improvements in yield components with higher fertilizer levels were reported by Jaliya *et al.* (2008) and Jena *et al.* (2015).

Among hybrids, HQPM 1 recorded superior cob length (19.5 cm), cob girth (16.4 cm), kernel rows per cob (17.1), kernels per row (42.3) and test weight (30.7 g), reflecting better assimilate partitioning efficiency. Differential performance of maize hybrids under varying nitrogen levels was also reported by Adhikari *et al.* (2021).

Grain and stover yield

Grain yield increased significantly with fertility level (Table 2). Application of 150% and 125% RDF produced 8535 and 7882 kg grain/ha, respectively, compared to 7204 kg/ha under 100% RDF, representing an 18.5% increase in maize productivity at 150% RDF over 100% RDF. Stover yield also increased from 8664 to 9665 kg/ha at 150% RDF. The yield enhancement under higher fertility may be attributed to improved vegetative growth and enhanced sink development. Similar responses of maize

Table 2. Yield attributes and yield of QPM hybrids as affected by varying fertility levels

Treatments	Cob length (cm)	Cob girth (cm)	No. of kernel rows/cob	No. of kernels/row	100-seed weight (g)	Grain yield (kg/ha)	Stover yield (kg/ha)
Main plot: Fertility level							
100 % RDF	17.8	15.8	15.9	36.0	27.4	7204	8664
125 % RDF	18.3	16.0	16.3	40.2	28.6	7882	9161
150 % RDF	18.8	16.3	16.6	42.1	30.3	8535	9665
SEm ±	0.19	0.10	0.34	0.95	0.34	183.17	175.28
CD (P = 0.05)	0.73	0.40	NS	2.90	1.74	719.23	688.24
CV (%)	3.5	2.2	7.2	8.1	4.1	8.0	6.7
Sub - plot: QPM hybrid							
APQH 1	18.7	16.2	16.1	41.2	29.1	8695	9983
APQH 5	17.9	16.0	16.0	41.0	28.7	8255	9500
HQPM 1	19.5	16.4	17.1	42.3	30.7	9110	10453
HQPM 5	17.7	15.5	15.8	38.6	26.6	5435	6717
SEm ±	0.18	0.40	0.25	0.58	0.74	170.54	180.74
CD (P = 0.05)	0.82	0.27	1.05	1.73	2.21	506.71	536.99
CV (%)	2.9	1.7	4.6	4.3	7.7	7.0	6.0
Interaction	NS	NS	NS	NS	NS	NS	NS

Table 3. Economics of QPM hybrids as affected by varying fertility levels

Treatments	Gross returns (Rs./ha)	Cost of cultivation (Rs./ha)	Net returns (Rs./ha)	B:C Ratio
Main plot: Fertility level				
100 % RDF	150563	65537	85026	2.30
125 % RDF	164735	67600	97135	2.44
150 % RDF	178391	69664	108727	2.56
SEm ±	3828		3828	0.06
CD (p = 0.05)	15031		15031	NS
CV (%)	8.0		13.6	8.0
Sub - plot: QPM hybrid				
APQH 1	181726	67600	114126	2.69
APQH 5	172532	67600	104932	2.55
HQPM 1	190405	67600	122805	2.81
HQPM 5	113591	67600	45990	1.68
SEm ±	3564		3564	0.05
CD (P = 0.05)	10590		10590	0.16
CV (%)	7.0		11.0	6.5
Interaction	NS	NS	NS	NS

to higher nitrogen application were reported by Singh *et al*. (2003) and Khan *et al*. (2011)

Hybrids differed significantly in productivity. HQPM 1 recorded the highest grain yield (9110 kg ha^{-1}), whereas HQPM 5 registered the lowest yield (5435 kg ha^{-1}). The grain yield of HQPM 1 was 4.8%, 10.4% and 67.6% higher over APQH 1, APQH 5 and HQPM 5, respectively. The superior performance of HQPM 1 may be attributed to its enhanced yield attributes under improved nutrient supply. Similar variation among maize hybrids under graded fertilizer levels was reported by Laghari *et* al. (2024). The interaction between fertility levels and hybrids was non-significant.

Economics

Economic returns increased with increasing fertility levels (Table 3). Cost of cultivation also increased with higher fertilizer application, from Rs. 65,537/ha under 100% RDF to Rs. 69,664/ha under 150% RDF due to additional fertilizer inputs. However, the increase in yield was proportionately higher, resulting in improved net returns from Rs. 85,026/ha under 100% RDF to Rs. 1,08,727/ha under 150% RDF, with a corresponding increase in B:C ratio from 2.30 to 2.56. The higher profitability at increased fertility levels may be attributed to enhanced nutrient availability leading to better growth, higher yield attributes and increased grain yield. Similar findings were reported by Kumar *et al*. (2005) and Laghari *et al.* (2024).

Among hybrids, HQPM 1 recorded the highest net returns (Rs. 1,22,805/ha) and B:C ratio (2.81), which may be due to its superior yield performance and efficient utilization of applied nutrients under rabi conditions.

Conclusion

Fertility levels significantly influenced growth, phenology, yield attributes, productivity and profitability of Quality Protein Maize during *rabi*, 2023–24. Application of 150% RDF (360:120:120 kg $N:P_2O_5:K_2O$/ha) and 125% RDF (300:100:100 kg $N:P_2O_5:K_2O$/ha) enhanced plant height, advanced flowering and improved cob characteristics, resulting in higher grain yield over 100% RDF along with increased stover yield and economic returns. Among the evaluated hybrids, HQPM1 consistently recorded superior yield attributes, highest grain yield and maximum profitability. Thus, cultivation of QPM hybrid HQPM1 under 150% RDF is recommended for achieving higher productivity and profitability during the *rabi* season in coastal Andhra Pradesh.

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