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Evaluation of Quality Protein Maize Genotypes for Yield and Profitability under Varying Fertility Levels

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***Abstract*:** A field experiment was conducted during *Kharif,* 2024 to evaluate the performance of Quality Protein Maize (QPM) hybrids under varying fertility regimes. The trial was laid out in a split-plot design with three fertility levels in the main plots 100% Recommended Dose of Fertilizers (RDF) (200:60:50 N:P_2O_5:K_2O kg ha^{-1}), 125% RDF (250:75:62.5 N:P_2O_5:K_2O kg ha^{-1}), and 150% RDF (300:90:75 N:P_2O_5:K_2O kg ha^{-1})] and nine QPM hybrids (IQPMH 2205, IQPMH 2204, APQWH8, APH6, AQWH5, IQMH 203, HM 8, HQPM 5 and APH1) in the sub-plots, replicated thrice. Application of 150% RDF significantly enhanced plant height, hastened flowering, improved cob traits and increased grain (6620 kg ha^{-1}) and stover yields (8293 kg ha^{-1}) as well as economic returns (₹73,727 ha^{-1} net returns with B:C ratio of 2.05). Among the hybrids, IQPMH 2204 was found superior recording the highest grain yield (7398 kg ha^{-1}), stover yield (9189 kg ha^{-1}) and profitability (₹93,507 ha^{-1} net returns with B:C ratio of 2.31). It is therefore concluded that cultivation of QPM hybrid *viz*. IQPMH 2204 under 150% RDF can be recommended for achieving higher productivity and profitability during *Kharif* season in Andhra Pradesh.

Keywords*:* Quality protein maize, Fertility levels, Grain yield, Economic returns, Andhra Pradesh

Maize (*Zea mays* L.) is one of the world's most important cereals, cultivated for food, feed and industrial uses. Globally, it ranks third after rice and wheat in terms of area and production and in India it occupies over 10 million hectares with an annual output of nearly 30 million tonnes. Beyond direct consumption, maize supports a wide range of industries including starch, ethanol, poultry feed and dairy nutrition, thereby contributing substantially to food, nutrition and livelihood security.

Despite its economic and dietary importance, conventional maize protein is deficient in lysine and tryptophan, two essential amino acids vital for human growth and efficient feed utilization in monogastric animals. Diets dominated by normal maize therefore lacks balanced protein quality and may contribute to malnutrition, particularly in regions where alternative protein sources such as pulses, milk and meat are scarce or unaffordable (Laskowski et al., 2019).

To overcome this limitation, researchers developed Quality Protein Maize (QPM) through conventional breeding. The improvement was achieved by incorporating the *opaque-2* (o2) gene, which elevates lysine and tryptophan content along with modifier genes that restore kernel hardness and agronomic desirability. QPM contains nearly twice the lysine and tryptophan levels of normal maize, offering a cost-effective solution to protein-energy malnutrition. Since it is a product of traditional breeding rather than genetic engineering, QPM represents a sustainable and widely acceptable form of biofortification (Milan-Carrillo et al., 2004, Denic et al., 2012). Adoption of QPM has been shown to improve child growth, enhance livestock productivity and strengthen food and nutritional security in several developing countries.

However, the success of QPM depends not only on its nutritional superiority but also on its agronomic performance and economic viability. Maize productivity is strongly influenced by fertilizer management, as adequate nutrient supply promotes vegetative growth, cob development, kernel filling and grain yield. Fertilizer dosage is therefore a critical determinant of yield and profitability. Insufficient application restricts productivity, whereas excessive use reduces economic efficiency and may lead to environmental problems.

Research has shown that fertilizer dosage influences important yield-contributing traits such as cob length, kernel row number and grain weight, which ultimately determine grain and stover yield (Asghar et al., 2010, Gul et al., 2015). At the same time, maize hybrids differ in their responsiveness to fertilizer levels due to genetic variation in nutrient-use efficiency and adaptability. Studying genotype × fertilizer interactions is thus essential for developing location-specific recommendations that maximize returns while ensuring sustainability.

Although QPM has been widely tested in different agro-ecological regions, information on its performance under variable fertilizer dosages in India remains limited. This knowledge gap is particularly evident in the sandy-loam soils of Andhra Pradesh, where farmers often apply fertilizers without precise guidance on hybrid-specific requirements. Identifying suitable QPM hybrids and optimal fertilizer regimes in such environments is important for enhancing both productivity and profitability while ensuring better nutritional outcomes.

MATERIAL AND METHODS

Experimental site and soil characteristics: The field experiment was conducted during the *kharif*, 2024 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 soils, slightly acidic in reaction (pH 6.92), with an electrical conductivity of 0.12 dS m^{-1} and organic carbon content of 0.47%. The available nutrient status was low in nitrogen (218 kg ha^{-1}) and potassium (106 kg K_2O ha^{-1}), medium in phosphorus (38 kg P_2O_5 ha^{-1}).

Weather during the crop season: Weather data recorded at the ARS meteorological observatory during the crop season from June to October, 2024 showed a total rainfall of 894.6 mm received over 59 rainy days (Table 1). The mean maximum temperature ranged from 31.5°C to 35.6°C, while mean minimum temperature varied between 24.8°C and 28.2°C. Relative humidity remained high, (85**%**) during the crop period.

Experimental design and treatments: 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 nine pre-release QPM hybrids. The fertility treatments included three levels (100 % RDF-200:60:50 kg NPK /ha, 125 % RDF- 250:75:62.5 kg NPK /ha and 150 % RDF -300:90:75 kg NPK /ha). The sub-plots were allotted to nine different QPM hybrids (IQPMH 2205, IQPMH 2204, APQWH8, APH6, AQWH5, IQMH 203 (C), HM 8 (C), HQPM 5 (C), APH1).

Crop management and data collection: Fertilizers were applied as per the respective treatments, with nitrogen supplied through urea in three equal splits at the basal, knee-high, and flowering stages; the entire phosphorus dose was applied through single superphosphate (SSP) at basal; and potassium was applied through muriate of potash (MOP) in two equal splits at basal and flowering. The crop was sown on 08 July 2024, with a spacing of 60 cm × 20 cm, ensuring a uniform plant population across treatments. Recommended agronomic practices were followed for timely weeding, earthing up and intercultural operations. Irrigations were provided at critical stages when rainfall was inadequate. Plant protection measures were undertaken as per ANGRAU recommendations to minimize pest and disease incidence. Five plants were selected at random and tagged for recording growth parameters, yield and yield attributes. Grain and stover yield from net plot area was converted into per hectare basis. Economic returns were worked out based on the prevailing market prices of inputs, cost of fertilizers and outputs. Returns per rupee invested were worked out by considering net returns and cost of cultivation.

Statistical analysis: The data were statistically analyzed using OPSTAT (online statistical analysis tools).

RESULTS AND DISCUSSION

Growth and phenology: Fertility management significantly influenced the plant height and phenological traits of QPM hybrids (Table 2). Increasing the nutrient supply from 100% to 150% RDF led to rise in plant height from 175.8 cm to 191.7 cm, indicating the strong vegetative response of maize to enhanced nutrient availability. Similar increases in vegetative growth with increased fertilizer application were earlier observed by Asghar *et al*. (2010) and Manea *et al*. (2015). The QPM hybrids exhibited pronounced variability in plant height, with IQPMH 2204 attaining the maximum height (194.1 cm), while APH6 recorded the shortest stature (170.7 cm) (Table 2). These differences likely arise from inherent genotypic variation in nutrient uptake and utilization efficiency, particularly nitrogen, which is a key determinant of vegetative growth and internode elongation. Sanchez et al. (2023) also highlighted that genotypic differences in nitrogen assimilation pathways significantly influence maize plant architecture.

Table 1. Weather data during the cropping season

Month	Rainfall (mm)	No. of rainy days	Temperature (°C)		Relative humidity (%)	
			Maximum	Minimum	Maximum	Minimum
June, 2024	182.6	13	34.6	28.0	77.8	62.9
July, 2024	134.2	12	32.8	28.2	81.3	75.4
August, 2024	328.3	12	35.6	24.8	88.8	77.8
September, 2024	170	14	31.5	25.8	91.3	73.5
October, 2024	79.5	8	33.4	25.4	86.6	73.6
Total/ Average	894.6	59	33.6	26.4	85.2	72.6

Plant and cob population were unaffected by fertility, but hybrids differed significantly, likely due to inherent differences in seed vigour, emergence rate and early stand establishment capacity among genotypes. Fertility levels affected flowering behavior of QPM hybrids. Increasing fertility hastened phenological events, as tasseling advanced from 51.1 days at 100% RDF to 49.5 days at 150% RDF, while silking was reduced from 52.9 to 51.5 days. This advancement of flowering under higher nutrient supply can be attributed to improved crop vigor and earlier attainment of reproductive competence. Among hybrids, APH1 was the earliest to flower, while IQPMH 2204 and HM 8 were comparatively late, indicating inherent genotypic differences. Similar trends of nutrient-induced earliness in maize phenology were reported by Murugudu et al. (2023).

Yield attributes: Yield attributing characters were significantly influenced by fertility levels (Table 3). Application of 150% RDF resulted in higher values of cob length (15.7 cm), cob girth (15.0 cm), kernel rows per cob (15.2) and kernels per row (32.2) compared to 100% RDF. This improvement may be attributed to better nutrient availability, which enhances root activity, reproductive development and assimilate translocation to developing cobs. Narayanaswamy and Siddaraju (2011) and Gul et al. (2015) also reported similar improvements in cob traits with balanced NPK application. Significant variation was also observed among hybrids. IQPMH 2204 recorded greater cob length (16.6 cm), girth (16.0 cm), kernel rows (17.1) and kernels per row (33.0) compared to other entries. These differences may be due to the inherent genetic potential of hybrids to utilize available nutrients effectively. Ullah et al. (2025) also emphasized the role of genotype-specific responses in determining yield attributes under variable nitrogen regimes.

Grain and stover yield: Grain and stover yields were positively influenced by increasing fertility levels (Table 3) Application of 150% RDF recorded significantly higher grain yield of 6620 kg/ha than observed at 100% RDF (5442 kg/ha) and 125% RDF (6097 kg/ha). Stover yield also followed a similar trend, increasing from 6870 kg/ha (100% RDF) to 8293 kg/ha (150% RDF). The increase in biomass and grain production under higher fertility levels may be attributed to improved vegetative growth, better cob development and enhanced source–sink relationship. Hargilas (2012), Owla et al. (2015) and Ghosh et al. (2009) also 0bserved that appropriate nutrient application supports yield improvements in maize. Hybrids differed noticeably in productivity. IQPMH 2204 recorded a grain yield of 7398 kg/ha and stover yield of 9189 kg/ha, outperforming the check and other hybrids. The enhanced performance of

Table 2. Growth and phenology of quality protein maize genotypes as affected by varying nutrient levels during *Kharif,* 2024

Treatments	Plant height (cm)	Plants ('000/ha)	Cobs ('000/ha)	Days to 50% tasselling	Days to 50% silking
Main plot: Fertility levels					
100 % RDF	175.8	77.9	72.2	51.1	52.9
125 % RDF	185.9	79.3	71.9	50.5	52.3
150 % RDF	191.7	80.5	73.1	49.5	51.5
CD (p = 0.05)	3.68	NS	NS	0.67	0.42
CV (%)	5.6	4.8	5.2	1.7	1.0
Sub - plot: QPM hybrids					
IQPMH 2205	183.4	79.2	72.5	49.7	51.7
IQPMH 2204	194.1	81.7	75.9	52.8	54.6
APQWH8	190.0	78.0	72.3	50.5	52.7
APH6	170.7	78.5	70.9	49.1	51.2
AQWH5	185.9	79.1	75.1	51.1	52.8
IQMH 203 (C)	188.2	80.2	74.1	49.8	51.2
HM 8 (C)	181.0	80.5	72.2	52.3	54.3
HQPM 5 (C)	185.6	77.0	65.8	51.3	53.1
APH 1	180.9	79.1	72.9	46.6	48.4
CD (p = 0.05)	6.15	1.63	3.00	0.46	0.57
CV (%)	5.5	2.1	4.3	0.9	1.1
Interaction	NS	NS	NS	NS	NS

Table 3. Yield attributes and yield of quality protein maize as affected by varying nutrient 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 levels							
100 % RDF	14.4	13.9	14.0	28.1	25.1	5441.6	6870.3
125 % RDF	15.1	14.4	14.5	29.8	26.2	6096.7	7358.1
150 % RDF	15.7	15.0	15.2	32.2	27.6	6620.1	8292.7
CD (P = 0.05)	0.49	0.5	0.36	1.09	0.61	417.9	739.2
CV (%)	4.3	4.6	3.3	4.8	3.1	9.1	12.7
Sub - plot: QPM hybrids							
IQPMH 2205	15.3	14.2	14.2	27.9	26.4	6083.6	7655.9
IQPMH 2204	16.6	16.0	17.1	33.0	32.5	7397.6	9189.3
APQWH8	15.2	13.7	13.1	29.8	26.4	5940.5	7275.1
APH6	13.9	13.9	13.6	27.4	21.3	5026.9	6062.0
AQWH5	15.9	15.3	16.5	31.7	28.2	6671.1	8314.2
IQMH 203(C)	15.7	14.7	15.2	31.3	27.3	6425.4	8092.2
HM 8 (C)	14.4	14.4	13.4	30.5	25.3	5256.6	6428.1
HQPM 5 (C)	15.1	14.0	14.0	30.0	26.5	5499.4	6921.2
APH 1	13.5	14.1	14.3	28.5	22.5	6174.1	7625.2
CD (P = 0.05)	0.73	0.78	0.65	1.23	1.72	491.7	708.7
CV (%)	5.1	5.7	4.7	4.3	6.9	8.5	9.9
Interaction	NS	NS	NS	NS	NS	NS	NS

Table 4. Economics of quality protein maize genotypes as affected by varying nutrient levels

Treatments	Gross returns (Rs./ha)	COC (Rs./ha)	Net returns (Rs./ha)	B: C Ratio
Main plot: Fertility levels				
100 % RDF	121086	68615	52471	1.77
125 % RDF	135663	71099	64564	1.91
150 % RDF	147311	73584	73727	2.05
CD (P = 0.05)	9554		9549.6	0.13
CV (%)	9.1		19.3	9.0
Sub - plot: QPM hybrids				
IQPMH 2205	135375	71099	64275	1.90
IQPMH 2204	164606	71099	93507	2.31
APQWH8	132189	71099	61089	1.86
APH6	111860	71099	40761	1.57
AQWH5	148443	71099	77344	2.08
IQMH 203(C)	142972	71099	71873	2.01
HM 8 (C)	116974	71099	45874	1.64
HQPM 5 (C)	122377	71099	51278	1.72
APH 1	137386	71099	66287	1.93
CD (P = 0.05)	10978.2		10978.3	0.15
CV (%)	8.6		18.1	8.5
Interaction	NS		NS	NS

IQPMH 2204 may be attributed to its prolonged vegetative growth, better cob development and efficient nutrient use. Khan et al. (2011) and Ullah et al. (2025 also emphasized the importance of genotype × nutrient interactions in determining yield potential under variable fertility conditions.

Economics: Economic returns were strongly influenced by both fertility levels and hybrid performance (Table 4). The 150% RDF treatment recorded net returns of ₹73,727/ha with a benefit–cost ratio of 2.05, reflecting improved profitability compared to lower fertility levels. Inadequate fertilizer application not only limited yield potential but also reduced economic efficiency. Kumar *et al*. (2015) observed that increased nutrient input enhances profitability, despite higher cultivation costs. Hybrids also differed in their economic performance. IQPMH 2204 achieved net returns of ₹93,507/ha with a B:C ratio of 2.31, followed by AQWH5 (₹77,344/ha; 2.08) respectively and IQMH 203 (₹71,873/ha, 2.01) respectively. These results emphasize that both genotype selection and nutrient management play a pivotal role in optimizing profitability, supporting the conclusions of Pal and Bhatnagar (2012) and Murugudu et al. (2023).

CONCLUSION

Fertility levels significantly influenced the growth, phenology, yield attributes, and productivity of QPM hybrids on sandy loam soils during *Kharif*, 2024. Application of 150% RDF (300:90:75 kg N:P_2O_5:K_2O/ha) promoted earlier flowering, improved cob traits and increased both grain and stover yields. Among the tested hybrids, IQPMH 2204 was the most productive and profitable, followed by AQWH5 and IQMH 203. Thus, cultivating IQPMH 2204 under 150% RDF is recommended for achieving high productivity and profitability of QPM under the agro-climatic conditions of Andhra Pradesh.

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