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# Influence of plant population and fertilizer levels on growth, yield and quality parameters of quality protein maize (*Zea mays* L.) in irrigated ecosystem

**Sharanabasappa HC and Basavanneppa MA**

**Abstract**

A field investigation was undertaken on "Influence of plant population and fertilizer levels on growth, yield and quality parameters of quality protein maize (*Zea mays* L.) in irrigated ecosystem" during the *Kharif* 2015 at Agriculture Research Station, Siruguppa. It is situated on the latitude of 15°38' N, longitude 76°54' E, 380 m elevation from MSL belongs to Northern Dry Zone (Zone 3) of Karnataka. The soil of the experimental site was medium deep black cotton soil with organic carbon content of 0.41 per cent, low in available N (220 kg $ha^{-1}$), medium in available phosphorus (21 kg $ha^{-1}$) and high in potassium (375 kg $ha^{-1}$) content. The experiment was laid out in a split plot design with three replications. Trail consisted of sixteen treatment combinations of four plant populations *viz*., $S_1$:1,11,111, $S_2$:83,333, $S_3$:74,074 and $S_4$:66,666 plants $ha^{-1}$ in main plots and four fertilizer levels, $F_1$:150:75:37.5, $F_2$:187.5:93.75:46.88, $F_3$:225:112.5:56.25 kg NPK $ha^{-1}$ and $F_4$:Nutrient Expert based target yield 10 t $ha^{-1}$(NE) in sub plots. The hybrid HQPM-1 was used in the investigation. The experimental results indicated that, among the plant populations, 1,11,111 plants $ha^{-1}$ recorded higher grain (7839 kg $ha^{-1}$), stover yield (13114 kg $ha^{-1}$) compared to other plant populations. But minimum total dry matter production (251.21 g $plant^{-1}$), number of green leaves (6.35/plant) and leaf area (2452 $cm^2$) were registered with higher plant population (1,11,111 plants $ha^{-1}$) compared to other plant populations. Higher protein content, oil per cent and starch contents were recorded with 66,666 plants $ha^{-1}$. Among the fertilizer levels significantly higher grain yield (8023 kg $ha^{-1}$) and stover yield (13434 kg $ha^{-1}$) was registered with the application of 225:112.5:56.25 NPK kg $ha^{-1}$ than other fertilizer levels. Similar trend in number of leaves, leaf area, leaf area index, plant height, protein, oil and starch contents were noticed with higher fertilize level compared to other fertilizer levels.

**Keywords:** Quality protein maize, plant population, fertilizer levels, nutrient expert, yield and quality parameters

## Introduction

Maize (*Zea mays* L) is one of the important versatile emerging crops having wider adaptability under varied agro-climatic conditions and it can be cultivated in different seasons and ecologies for multiple purposes. Globally, it is popularly called as queen of cereals due to its highest genetic yield potential among the cereals. Maize is the third most important cereal crop in the world next to wheat and rice (Anon., 2010) [2]. In India, it is cultivated over an area of 9.43 m ha with a production and productivity of 24.35 m t and 2583 kg $ha^{-1}$, respectively (*Anon*., 2015) [4]. The predominant maize growing states that contributes more than 80 per cent of the total maize production in Karnataka (16.5%) (*Anon*., 2015) [4]. Calorie yield content in maize is two and halftimes more than that in paddy and wheat (Karim, 1992) [19]. In spite of several important uses, maize has an inbuilt drawback of being deficient in two essential amino acids, *viz.*, lysine and tryptophan. This leads to poor protein utilization and low biological value of traditional maize genotypes. To overcome this problem, plant breeders have developed quality protein maize (QPM) by incorporating Opaque-2 gene, which is particularly responsible for enhancing lysine and tryptophan content of maize endosperm protein. QPM looks and taste like normal maize with same or higher yield potential, but it contains nearly twice the quantity of essential amino acids, lysine and tryptophan which makes it richer in quality proteins (*Anon*., 2009) [2].

The newly released varieties have the potential to give more yields. Agronomic practices such as seed rate, plant population and fertilizer management are known to affect crop environment, which influence the growth and ultimately the yield (Lomte and Khuspe, 1987) [22]. Optimum plant population and nitrogen (N) levels should be maintained to exploit maximum natural resources, such as nutrients, sunlight, and soil moisture, to ensure satisfactory growth and yield. High density is undesirable because it encourages inter plants competition for resources. N has been found to be the most crucial nutrient for maize production (Sanjeev and Bangarwa, 1997) [31]. Biomass production of a crop largely depends on the function of leaf area development and consequential photosynthetic activity (Natr, 1992) [26]. Photosynthetic rate can substantially be increased with N fertilization. Application of N fertilizer has also been reported to have significant effect on grain yield and quality of maize (Khot and Umrani, 1992) [20]. Hardas and Karagianne-Hrestou (1985) [15] reported that 180 kg N ha$^{-1}$ was optimum for maize, while Singh *et al*. (2000) [34] observed that application of 200 kg N ha$^{-1}$ increased grain yield of maize. However, a substantial percentage of applied N is also lost due to volatilization, leaching, and denitrification. Therefore, N should be applied in such a way that would maximize its utilization for grain production. Keeping these points in view, the present investigation was carried out to study influence of plant population and fertilizer levels on growth, productivity and quality parameters of quality protein maize (*Zea mays* L.) in Tungabhadra Project area is need of the hour.

## Materials and Methods

A field investigation was undertaken on "Influence of plant population and fertilizer levels on growth, yield and quality parameters of quality protein maize (*Zea mays* L.) in Tunga Bhadra Project Area (TBP)" during the *Kharif* 2015 at Agriculture Research Station, Siruguppa. It is situated on the latitude 15$^0$38' N, longitude 76$^0$54'E, 380 m elevation from MSL belongs to Northern Dry Zone (Zone 3) of Karnataka. The experimental site soil was clay loam in texture, neutral pH (7.94) and low in electrical conductivity (0.37 dSm$^{-1}$). The soil organic carbon content was 0.41 per cent and soil was low in available N (220 kg ha$^{-1}$), medium in available phosphorus (21 kg ha$^{-1}$) and high potassium (375 kg ha$^{-1}$). The experiment consisted of sixteen treatment combinations of four plant populations *viz*., $S_1$:1,11,111, $S_2$:83,333, $S_3$:74,074 and $S_4$:66,666 plants ha$^{-1}$ in main plots and fertilizer levels $F_1$:150:75:37.5, $F_2$:187.5:93.75:46.88, $F_3$:225:112.5:56.25 kg NPK ha$^{-1}$ and $F_4$:Nutrient Expert based target yield 10 t ha$^{-1}$ in sub plots. For Nutrient Expert based fertilizer recommendation ready recknor software developed by International Plant Nutrition Institute (IPNI), 2014 was used for the study. The experiment was laid out in spilt plot design with three replications. The hybrid HQPM-1 was used in the investigation. At basal, half of nitrogen, entire dose of phosphorus and potassium in the form of Urea, Di ammonium phosphate (DAP) and Muriate of potash (MOP) were applied as per the treatments. Remaining half of recommended nitrogen was top dressed at 30 and 45 days after sowing (DAS). Immediately after sowing Atrazine 50% WP @ 1.0 kg *a.i* ha$^{-1}$ was applied to control weeds as pre emergent. Further, bicycle weeder was used at 20 DAS and hand weeding has been done at 35 and 50 days after sowing to manage weeds. Grain and Stover yield from net plot area was converted into per hectare basis. The quality parameters like grain moisture (%), protein (%), starch (%) and oil content (%) are estimated by using "Grain Analyzer".

## Results and Discussion

### Effect of plant population and fertilizer levels on yield

The experimental results presented in Table 1 revealed that significantly higher grain (7839 kgha$^{-1}$) and Stover yield (13114 kg ha$^{-1}$) was registered with 1,11,111 plants ha$^{-1}$ due to higher plant population per unit area and plant height (205.43 cm). These results are in conformity with findings of Chandankar *et al*. (2005) [9] at Akola who reported that increase in plant height of maize hybrid (Pro Agro 4640) with higher plant population (111111 plants ha$^{-1}$) than with lower plant population (83333 plants ha$^{-1}$). In the present investigation, the reverse case was with minimum total dry matter production (251.21 g plant$^{-1}$), number of green leaves (6.35) and leaf area (2452 cm$^2$) were observed with higher plant population (1,11,111 plants ha$^{-1}$) compared to other plant populations (Table 1). Significantly less grain yield (6907 kg ha$^{-1}$) and stover yield (11397 kg ha$^{-1}$) was showed with 66,666 plants ha$^{-1}$ (Table 1) and it was reverse case with higher total dry matter production (341.84 g plant$^{-1}$), number of green leaves per plant (7.01), leaf area (3022 cm$^2$) and plant height (186.89cm) compared to other plant populations. However, it was on par with 83,333 plants ha$^{-1}$ (7648 kg ha$^{-1}$ and 12701 kg ha$^{-1}$, grain and Stover yield, respectively). These results are in agreement with the findings of Muhammad *et al.* (2010) [24] and Gaurav *et al.* (2013) [13]. In another study conducted elsewhere, reported that linear increase in fodder yield with increasing in plant density was also noticed by Ashok Kumar (2009) [6] and Kar *et al.* (2006) [18]. In the present study, the increased fertilizer levels enhanced the grain yield of quality protein maize. Application of 225:112.5:56.25 kg NPK ha$^{-1}$ registered significantly higher grain and stover yield (8023 kg ha$^{-1}$ and 13434 kg ha$^{-1}$, respectively) compared to other nutrient levels. This higher yield was due to higher total dry matter production (342.6 g/plant) compared to other fertilizer levels. Similar trend was also followed in plant height. These results are in accordance with findings of Muhammad *et al*. (2010) [24]; Singh *et al.* (1997) [32, 33] and Nandita *et al*. (2015) [25]. In the present study, the increased grain yield in quality protein maize was noticed with application of 225:112.5:56.25 kg NPK ha$^{-1}$ was mainly attributed to readily available form of nutrients which would have been easily taken up by the plant for growth and development. Luxuriant growth resulting from fertilizer application leads to larger dry matter production (Obi *et al.*, 2005) [27] owing to better utilization of solar radiation and more nutrient (Saeed *et al.*, 2001) [30]. In the present study, significantly low grain and stover yield was recorded with application of 150:75:37.5 kg NPK ha$^{-1}$ (6606 kg ha$^{-1}$ and 11391 kg ha$^{-1}$, respectively) than other nutrient levels and it was mainly due to less total dry matter production per plant (Table 1).

### Effect of plant population and fertilizer levels on growth parameters

The higher leaf area index (3.17) recorded with plant population of 1, 11,111 plants ha$^{-1}$ compared to 83,333, 74,074 and 66,666 plants ha$^{-1}$. The increase in LAI with increase in plant density was due to more number of plants per unit area. Similar research findings were also reported by of Chougule (2003) [11], Gaurav *et al.* (2013) [13] and Suryavanshi *et al.* (2008) [37]. The plant height and dry matter production increased with advances in crop age from 30 DAS to harvesting stage. It was found that among different plant population, higher plant population of 1, 11,111 ha$^{-1}$ registered maximum plant height (205.43 cm) and found to be significant over plant population of 66,666, 74,074 and 83,333 plants ha$^{-1}$ (Table 1). This clearly indicates that increase in number of plants per unit area beyond optimum level certainly reduced the amount of light availability to the individual plant, especially to lower leaves due to shading. As the intensity of shading increases due to more population, the plant tends to grow taller; such increase in height of the plant at higher population was reported by Ashwani *et al.* (2015) [7], Zarapkar (2006) [39] and Bhatt (2012) [8].

Significantly higher leaf area with application of 225:112.5:56.25 NPK kg ha$^{-1}$ compared to 150:75:37.5 NPK kg ha$^{-1}$, 187.5:93.75:46.88 NPK kg ha$^{-1}$ and nutrient expert based target yield 10 t ha$^{-1}$ ($NE_{10}$). Significantly higher in leaf area and leaf area index was registered with application of 225:112.5:56.25 kg NPK ha$^{-1}$ is mainly due to increased number of green leaves per plant and also due to readily available nitrogen in soil and for higher absorption of nutrients. These results are in conformity with findings of Arun Kumar *et al.* (2007), Kaledhonkar (2003) [16] and Kunjir (2004). Application of higher doses of fertilizer level i.e., 225:112.5:56.25 NPK kg ha$^{-1}$ recorded significantly higher plant heights (202.54 cm) over 150:75:37.5 NPK kg ha$^{-1}$ (186.83 cm) and it were on par with 187.5:93.75:46.88 NPK kg ha$^{-1}$ (Table 1). Such increase in height of the plant was reported by Channabasavanna *et al*. (2002) [10], Nandita *et al.* (2015) [25] and Roshan *et al.* (2013) [29].

**Effect of plant population and fertilizer levels on quality parameters**

The protein content in quality protein maize (Table 2) was significantly higher under plant density of 66,666 plants ha$^{-1}$ (11.69%) compared to 1,11,111 plants ha$^{-1}$ (10.01%). This was mainly attributed to the higher nitrogen values in the quality protein maize. Similar results were also reported by Kar *et al.* (2006) [18] and Gosavi and Bhagat (2009) [14]. In the present study similarly oil per cent in quality protein maize was also significantly higher with plant density of 66,666 plants ha$^{-1}$ (7.33%) compared to plant density of 1,11,111 plants ha$^{-1}$ (6.17%) but it was on par with plant density of 83,333 plants ha$^{-1}$ (7.02%). Further, starch content was greatly influenced by plant density. Lower plant density (66,666 plants ha$^{-1}$) produced significantly higher starch content (68.46%) when compared to rest of plant densities and it was on par with 74,074 plants ha$^{-1}$(67.21%). The least starch content was noticed under higher planting density of 1,11,111 ha$^{-1}$ (63.78%). This was due to higher availability of resources and better photosynthetic and other physiological activity of the individual plants under the low plant density which was reported by Gosavi and Bhagat (2009) [14], Raja (2001) [28] and Sukanya *et al.* (2000) [36]. Moisture content in quality protein maize was not statistically influenced by different planting density and nutrient levels under irrigated condition.

**Table 1:** Grain yield, stover yield and growth parameters of quality protein maize as influenced by plant population and fertilizer levels under irrigation

| Treatments | Grain yield (kg ha$^{-1}$) | Stover yield (kg ha$^{-1}$) | Total dry matter production (g plant$^{-1}$) | Number of green leaves/plant | Leaf area (cm$^2$) | Leaf area index | Plant height (cm) |
|---|---|---|---|---|---|---|---|
| **Plant populations** | | | | | | | |
| $S_1$: 1,11,111 (45 cm x 20 cm) | 7839 | 13114 | 251.21 | 6.35 | 2452 | 2.72 | 205.43 |
| $S_2$: 74,074 (45 cm x 30 cm) | 7181 | 12067 | 311.57 | 6.58 | 2682 | 1.99 | 190.99 |
| $S_3$: 83,333 (60 cm x 20 cm) | 7648 | 12701 | 283.12 | 6.43 | 2617 | 2.20 | 197.07 |
| $S_4$: 66,666 (75 cm x 20 cm) | 6907 | 11397 | 341.84 | 7.01 | 3022 | 2.01 | 186.89 |
| S.Em.± | 135 | 210 | 5.73 | 0.12 | 99 | 0.04 | 3.43 |
| C.D. (P=0.05) | 469 | 727 | 19.83 | 0.42 | 341 | 0.14 | 11.86 |
| **Fertilizer levels** | | | | | | | |
| $F_1$: 150:75:37.5 NPK kg ha$^{-1}$ | 6606 | 11391 | 255.39 | 5.90 | 2441 | 2.00 | 186.83 |
| $F_2$: 187.5:93.75:46.88 NPK kg ha$^{-1}$ | 7598 | 12432 | 305.11 | 6.73 | 2680 | 2.25 | 197.97 |
| $F_3$: 225:112.5:56.25 NPK kg ha$^{-1}$ | 8023 | 13434 | 342.60 | 7.30 | 2975 | 2.46 | 202.54 |
| $F_4$: Nutrient Expert based target yield 10 t ha$^{-1}$ ($NE_{10}$) | 7348 | 12022 | 284.64 | 6.43 | 2677 | 2.20 | 193.05 |
| S.Em.± | 108 | 200 | 7.87 | 0.10 | 102 | 0.08 | 2.95 |
| C.D. (P=0.05) | 316 | 583 | 22.96 | 0.30 | 297 | 0.24 | 8.60 |
| **Interactions** | | | | | | | |
| S.Em.± | 216 | 339 | 15.73 | 0.20 | 204 | 0.16 | 5.89 |
| C.D. (P=0.05) | NS | NS | NS | NS | NS | NS | NS |

NS: Non significant

**Table 2:** Quality parameters of quality protein maize as influenced by plant population and fertilizer levels under irrigation

| Treatments | Protein content (%) | Oil content (%) | Moisture content (%) | Starch content (%) |
|---|---|---|---|---|
| **Plant populations** | | | | |
| $S_1$: 1,11,111 (45 cm x 20 cm) | 10.01 | 6.17 | 12.61 | 63.78 |
| $S_2$: 74,074 (45 cm x 30 cm) | 10.52 | 7.02 | 12.64 | 67.21 |
| $S_3$: 83,333 (60 cm x 20 cm) | 10.13 | 6.71 | 12.66 | 64.40 |
| $S_4$: 66,666 (75 cm x 20 cm) | 11.69 | 7.33 | 12.61 | 68.46 |
| S.Em.± | 0.22 | 0.23 | 0.04 | 1.02 |
| C.D. (P=0.05) | 0.76 | 0.78 | NS | 3.51 |
| **Fertilizer levels** | | | | |
| $F_1$: 150:75:37.5 NPK kg ha$^{-1}$ | 10.03 | 6.30 | 12.67 | 63.79 |
| $F_2$: 187.5:93.75:46.88 NPK kg ha$^{-1}$ | 10.63 | 6.87 | 12.60 | 66.71 |
| $F_3$: 225:112.5:56.25 NPK kg ha$^{-1}$ | 11.38 | 7.42 | 12.64 | 69.13 |
| $F_4$: Nutrient Expert based target yield 10 t ha$^{-1}$ ($NE_{10}$) | 10.32 | 6.63 | 12.61 | 64.21 |
| S.Em.± | 0.23 | 0.16 | 0.04 | 1.17 |
| C.D. (P=0.05) | 0.68 | 0.46 | NS | 3.43 |
| **Interactions** | | | | |
| S.Em.± | 0.47 | 0.31 | 0.09 | 2.35 |
| C.D. (P=0.05) | NS | NS | NS | NS |

NS: Non significant

The protein and starch content of quality protein maize (Table 2) was also significantly higher with application of 225:112.5:56.25 NPK kg $ha^{-1}$ (11.38 and 69.13%, respectively) over 150:75:37.5 NPK kg $ha^{-1}$. However, it was closely followed by application of 187.5:93.75:46.88 NPK kg $ha^{-1}$ (10.63 and 66.71%, respectively). It was mainly attributed to the higher nitrogen availability to the quality protein maize. Studies showed significant increase in corn yield and protein content but, decreased corn oil and starch content by N fertilization Miao *et al*. (2007) [23]. Similar variations in N and crude protein content of the grain in different genotypes are reported by Umesh *et al*. (2014) [38]. Similar results of protein content with N management obtained by Dalvi *et al*. (2009) [12] and Kamalakumari and Singaram (1996) [17]. In the present study, similarly oil content in quality protein maize (Table 2) was also significantly higher with application of 225:112.5:56.25 NPK kg $ha^{-1}$ (7.42%) compared to 150:75:37.5 NPK kg $ha^{-1}$ (6.30%). Differences in corn grain starch due to N application were also opined by Kamalakumari and Singaram (1995).

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