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PRODUCTIVITY OF QUALITY PROTEIN MAIZE (*Zea mays* L.) AND SOIL FERTILITY AS INFLUENCED BY PLANT POPULATION AND FERTILIZER LEVELS UNDER IRRIGATED ECOSYSTEM

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ABSTRACT
A field experiment was conducted at Agriculture Research Station, Siruguppa, Karnataka during the *Kharif* 2015, to study the effect of plant density and fertilizer levels on yield and soil properties of quality protein maize (*Zea mays* L.) under irrigated condition. The soil of the experimental site was clay loam in texture with organic carbon content of 0.41%, low available N (220 kg ha^{-1}), medium in available phosphorus (21 kg ha^{-1}) and high potassium (375 kg ha^{-1}) content. The experiment was laid out in a split plot design with three replications. The hybrid HQPM-1 was used in the investigation. Treatments 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 experimental results revealed that, among the plant density 1, 11,111 plants ha^{-1} recorded higher grain (7839 kg ha^{-1}), stover yield (13114 kg ha^{-1}), uptake of N,P and K (231.4 kg ha^{-1}, 57.60 kg ha^{-1} and 188.87 kg ha^{-1}, respectively) compared to rest of the plant densities. But higher available N, P_2O_5 and K_2O (235.20, 38.76 and 326.49 kg ha^{-1}, respectively) was recorded in plant density of 66,666 plants ha^{-1} compared to other plant densities. 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}. Similarly maximum uptake of nitrogen (239.59 kg ha^{-1}), phosphorus (60.84 kg ha^{-1}) and potassium (210.02 kg ha^{-1}) was found in the same fertilizer dose. Higher available N, P_2O_5 and K_2O (242.20, 40.55 and 322.74 kg ha^{-1}, respectively) was noticed in the higher level of fertilizer dose compared to other fertilizer levels.

KEY WORDS: Quality protein maize, plant density, fertilizer levels, Nutrient Expert, nutrient uptake and soil fertility.

INTRODUCTION
Globally, maize (*Zea mays* L.) is known as queen of cereals due to its highest genetic yield potential among the cereals and it is one of the most versatile emerging crop having wider adaptability under varied agro-climatic conditions. Maize (*Zea mays* L.) is the third most important grain crop in the world next to wheat and rice (Anon., 2010). In India, it is cultivated over an area of 9.43 m ha with a production and productivity of 24.35 m t and 2583kg ha^{-1}, respectively (*Anon,* 2015). The predominant maize growing states that contributes more than 80 per cent of the total maize production in Karnataka (16.5%) (*Anon,* 2015). Calorie yield content in maize is two and halftimes more than that in paddy and wheat (Karim, 1992). 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, maize 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).

The newly released varieties have the potential to produce 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). Optimum 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 important nutrient for maize production (Sanjeev and Bangarwa, 1997). Biomass production of a crop largely depends on the function of leaf area development and consequential photosynthetic activity (Natr, 1992). 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). Hardas and Karagianne-Hrestou (1985) reported that 180 kg N ha^{-1} was optimum for maize, while Singh *et al*. (2000) 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 productivity of quality protein maize (*Zea mays* l.) and soil fertility as influenced by plant population and fertilizer levels under irrigated ecosystem.

MATERIALS & METHODS

A field experiment was conducted during the *kharif* 2015 at Agriculture Research Station, Siruguppa, Karnataka, 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 experiment was laid out in spilt plot design. 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 hybrid HQPM-1 was used in the investigation. The experiment consisted of sixteen treatment combinations of four plant densities 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_3:225:112.5:56.25kg 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. 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. During the field experiment, a composite soil sample was collected from experimental plot before sowing and after the crop harvest from each plot. The collected soil samples were dried under shade, powdered using pestle and mortar and passed through 2 mm sieve and preserved for analysis. For organic carbon analysis, the 2 mm sieved soil samples were subjected for further grinding and passed through 0.2 mm sieve. Available nitrogen in soil was determined by alkaline potassium permanganate method as described by Subbiah and Asija (1956). Available phosphorous was determined by Olsen's method (Olsen *et al*., 1954) by using Systronics UV visible Spectrophotometer (Model: 117). Available potassium was extracted from soil using neutral normal ammonium acetate (pH 7.0) and the content of potassium in the solution was estimated by Systronics Flame Photometer (Model: 128) (Jackson, 1973). The collected plant samples at the time of harvest were dried at 60 ^oC in a hot air oven, powdered using a grinder fitted with stainless steel blades and preserved in polythene covers for further analysis**.** The nitrogen in plant samples was determined by Kjeldahls method as described by Jackson (1973). In this method, a powdered sample of 0.5 g was digested with concentrated H_2SO_4 in presence of digestion mixture (K_2SO_4:$CuSO_4.5H_2O$: Selenium powder in the proportion of 100:20:1) and distilled under alkaline medium. The liberated NH_3 was trapped in boric acid containing mixed indicator and titrated against standard H_2SO_4. A powdered sample of 0.5 g was pre-digested with 5 ml of concentrated HNO_3 and again digested with a di-acid mixture (HNO_3: $HClO_4$ in 10:4 ratio). Volume of the digest was made up to 100 ml with distilled water and preserved for P and K analysis (Jackson, 1973). The total phosphorus content in plant sample was determined by taking a known volume of the digested samples by adopting the Vanadomolybdo phosphoric yellow colour method as described by Jackson (1973). The total potassium content of the di-acid digested plant samples were estimated by atomizing the digested and diluted sample to a calibrated flame photometer under suitable measuring conditions as described by Jackson (1973). The experimental data were analyzed statistically. The uptake of nutrients by different parts of maize plants was worked out by multiplying the nutrient concentration and dry matter yield of the plant part using the following formula:

$$\text{Nutrient uptake (kg ha} - {}^{1}) = \frac{\text{Nutrient concentration (\%)}}{100} x \text{ dry weight (kg ha} - {}^{1}$$

RESULTS & DISCUSSION

Significantly higher grain (7839 kg/ha^{-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) at Akola who reported that increase in plant height of maize hybrid (Pro Agro 4640) with higher plant density (111111 plants ha^{-1}) than with lower planting density (83333 plants ha^{-1}). In the present investigation, the reverse case was with minimum total dry matter production (251.21 g/plant), test weight (23.76 g) and cob weight (157.83 g) 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 recorded with 66,666 plants ha^{-1} (Table 1) and it was reverse case with higher total dry matter production (341.84 g/plant), hundred seed weight (27.10g) and cob weight (195.75 g/plant) 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 results of Muhammad *et al.* (2010) and Gaurav *et al*. (2013). In another study conducted elsewhere, reported that linear increase in fodder yield with increasing in plant density was also noticed by Ashok Kumar (2009) and Kar *et al.* (2006). In the present study, the increased fertilizer levels increased the grain yield of maize i.e., 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 fertilizer levels. This higher yield was due to higher total dry matter production (342.6 g/plant), test weight (27.23g) and cob weight (202.54 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); Singh *et al.* (1997) and Nandita *et al*. (2015). In the present study, the increased grain yield in quality protein maize was 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) owing better utilization of solar radiation and more nutrient (Saeed *et al.*, 2001). 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 fertilizer levels and it was mainly due to less total dry matter production per plant, test weight and cob weight per plant (Table 1).

TABLE 1. Grain yield, stover yield, total dry production and plant height of quality protein maize as influenced by plant density and fertilizer levels under irrigated condition

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Total dry matter production (g plant^{-1})	Hundred seed weight (g)	Cob weight plant^{-1} (g)	Plant height (cm)
Plant population						
S_1: 1,11,111 (45 cm x 20 cm)	7839	13114	251.21	23.76	157.83	205.43
S_2: 74,074 (45 cm x 30 cm)	7181	12067	311.57	25.06	184.33	190.99
S_3: 83,333 (60 cm x 20 cm)	7648	12701	283.12	24.64	181.67	197.07
S_4: 66,666 (75 cm x 20 cm)	6907	11397	341.84	27.10	195.75	186.89
S.Em.±	135	210	5.73	0.50	7.01	3.43
C.D. (P=0.05)	469	727	19.83	1.72	24.27	11.86
Fertilizer levels						
F_1: 150:75:37.5 NPK kg ha^{-1}	6606	11391	255.39	23.23	166.75	186.83
F_2: 187.5:93.75:46.88 NPK kg ha^{-1}	7598	12432	305.11	25.91	179.33	197.97
F_3: 225:112.5:56.25 NPK kg ha^{-1}	8023	13434	342.60	27.23	203.00	202.54
F_4: Nutrient Expert based target yield 10 t ha^{-1} (NE_{10})	7348	12022	284.64	24.20	170.50	193.05
S.Em.±	108	200	7.87	0.54	7.82	2.95
C.D. (P=0.05)	316	583	22.96	1.59	22.84	8.60
Interaction						
S.Em.±	216	339	15.73	1.09	15.65	5.89
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS

NS: Non significant

TABLE 2. Available nitrogen, phosphorus and potassium in soil after of the harvest of quality protein maize as influenced by plant density and fertilizer levels under irrigated condition

Treatments	Available nutrients (kg ha^{-1})			Nutrients uptake (kg ha^{-1})		
	N	P_2O_5	K_2O	N\`	P\`	K
Plant density						
S_1: 1,11,111 (45 cm x 20 cm)	203.98	17.24	281.17	231.34	57.60	188.87
S_2: 74,074 (45 cm x 30 cm)	221.20	36.57	306.00	196.06	47.81	165.86
S_3: 83,333 (60 cm x 20 cm)	215.32	29.07	294.84	210.58	53.50	181.18
S_4: 66,666 (75 cm x 20 cm)	235.20	38.76	326.49	180.99	43.45	160.69
S.Em.±	5.22	1.12	6.07	4.28	1.65	3.94
C.D. (P=0.05)	18.07	3.88	21.02	14.81	5.70	13.63
Fertilizer levels						
F_1: 150:75:37.5 NPK kg ha^{-1}	197.40	20.99	282.60	172.67	41.40	140.45
F_2: 187.5:93.75:46.88 NPK kg ha^{-1}	222.88	31.90	307.50	212.23	52.71	179.57
F_3: 225:112.5:56.25 NPK kg ha^{-1}	242.20	40.55	322.74	239.59	60.84	210.02
F_4: Nutrient Expert based target yield 10 t ha^{-1} (NE_{10})	213.22	28.21	295.65	194.48	47.41	166.57
S.Em.±	3.36	1.41	5.52	3.19	1.46	4.49
C.D. (P=0.05)	9.79	4.12	16.11	9.32	4.26	13.11
Interactions		\`				
S.Em.±	6.71	2.82	11.04	6.39	2.92	8.98
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS

NS:Non significant

Significantly higher availability of nutrients in soil was recorded with plant population of 66,666 plants ha^{-1} nitrogen (235.20 kg ha^{-1}), phosphorus (38.76 kg ha^{-1}) and potassium (326.49 kg ha^{-1}) in soil compared to other plant population (Table 2). The minimum available (203.98, 17.24 and 281.17 kg N P_2O_5 K_2O ha^{-1}, respectively) was noticed with higher plant population of 1,11,111 ha^{-}^{1}(Table 2). Similar results soil available nitrogen was reported by Arun Kumar *et al.* (2009) in baby corn. In the present investigation significantly higher available nitrogen (242.20 kg ha^{-1}), phosphorus (40.55 kg ha^{-1}) and potassium (322.74 kg ha^{-1}) in soil was observed with application of 225: 112.5: 56.25 kg NPK ha^{-1} compared to other fertilizer levels (Table 2). The least available nutrients were recorded under application of 150:75:37.5 kg NPK ha^{-1} (197.40, 20.99 and 282.60 available N P_2O_5 K_2O kg ha^{-1}, respectively).

Nutrient uptake is the function of nutrient concentration in plant parts and dry matter yield of the crop. Higher plant population of 1,11,111 plants ha^{-1} have registered higher total uptake of nutrients (231.34, 57.60 and 188.87 kg NPK ha^{-1}, respectively) over other plant population (Table 2). Availability of nutrients in soil with the plant population of 1,11,111 plants ha^{-1} resulted in higher uptake of nutrients and led to lower available nitrogen (203.98 kg ha^{-1}), phosphorus (17.24 kg ha^{-1}) and potassium (281.17 kg ha^{-1}) in soil and it was mainly due to higher grain yield and that might have attributed to higher uptake of nutrients which ultimately lowered the available nutrients in soil; these results are in accordance with the findings of Kar *et al.* (2006); Singh *et al.* (1997); Sahoo and Mahapatra (2007) and Ashok Kumar (2009) in maize and sweet corn, respectively.

Application of higher nitrogen resulted in higher dry matter production and nutrient uptake and it is the function of nutrient concentration in plant parts and dry matter yield of the crop. Application of 225:112.5:56.25 NPK kg ha^{-1} recorded significantly higher nitrogen uptake (239.59 kg ha^{-1}) compared to other fertilizer levels. Whereas application of 150:75:37.5 NPK kg ha^{-1} resulted in least nitrogen uptake (172.67 kg ha^{-1}) than rest of the fertilizer levels (Table 2). These results are in accordance with the findings of Reddiramer and Reddy, (2007), Rana and Choudhary (2006). Significantly higher uptake of P and K was recorded with application of 225:112.5:56.25 kg NPK ha^{-1} (60.84 and 210.02 kg ha^{-1}, respectively) compared to other fertilizer levels. Ananthi *et al.* (from their study at Coimbatore on sandy loam soils during *kharif* season reported that uptake of N and P increased with increase in N level from 150 to 200 kg ha-^{1} and phosphorus from 75to 100 kg P2O5 ha-^{1}.

The minimum P and K uptake was recorded with application of 150:75:37.5 kg NPK ha^{-1} (41.40 and140.45 P and K kg ha^{-1}, respectively). It is due to application of higher amount of P and K in which might have increased the uptake of P and K by quality protein maize

REFERENCES

Ananthi, T., Amanullah, M.M. and Subramanian, K.S. (2010) Influence of *mycorrhiza* and synthetic fertilizers on soil nutrient status and uptake in hybrid maize. *Madras Agril J*., 97(10-12):374-378.

Anonymous (2009) Quality protein maize for food and nutritional security in India. Research bulletin from Directorate of maize research ICAR, Pusa, New Delhi, pp: 1-12.

Anonymous (2010) Grain Zea production maps and statistics. http://www. fas.usda.gov / psdonline/

Anonymous (2015) Annual report of Indian institute of maize Research, ICAR New Delhi.

Arun Kumar, K., Karuna Sagar, G., Chandrika, V. and Reddy, P.M. (2009) Influence of integrated nitrogen management on yield, nitrogen uptake, soil fertility status and economics of baby corn. *Indian J. Agric. Res.,* 43(3): 227-229.

Ashok Kumar. (2009) Production potential and nitrogen use efficiency of sweet corn (*Zea mays* L.) as influenced by different planting densities and nitrogen levels. *Indian J. Agric. Sci*., 79(5): 351-355.

Chandankar, M.M., Ghanbahadur, M.R. and Shinde, V.S. (2005) Yield and economics of maize as influenced by FYM, N, P, K and plant density. *Ann plant Physiol*. 19(2): 172-174.

Gaurav, M., Singh R.N. & Rakesh, K**.** (2013) Growth, yield, nutrient uptake and net return of .sweet corn (*Zea mays Saccharata* Strut.) with different fertilizer levels, plant densities and sulphur nutrition. *Curr. Advan. Agri. Sci.,*5(2):201-204.

Hardas, G. and Karagianne-Hrestou, M. (1985) Long-term fertilizer trail in the Kopais area with a 2-year rotation of maize and wheat. The effect of NPK application on yield. *Field Crops Research*, 9:81–90.

Jackson, M.L. (1973) *Soil Chemical Analysis*, Prentice Hall of India, Pvt. Ltd., New Delhi, p. 498.

Kar, P.P., Barik, K.C., Mahapatra, P.K., Rath, L.M., Bastia, D.K. and Khanda, C.M. (2006) Effect of planting geometry and nitrogen on yield, economics and nitrogen uptake of sweet corn (*Zea mays*). *Indian J. Agron*., 51(1): 43-45.

Karim R. (1992) *Studies on Maize in Bangladesh*. Dhaka, Bangladesh: International Food Policy Research Institute, BFPP.

Khot, R.B. and Umrani, N.K. (1992)Seed yield and quality parameters of "African Tall" maize as influenced by spacing and level of nitrogen. *Indian Journal Of Agronomy*, 1992; 37:183–184.

Lomte, M.H. and Khuspe, V.S. (1987) Effect of plant densities, P levels and antitranspirants on the yield of summer groundnut. *Journal of Maharashtra Agricultural Universities*,12(1):28-30.

Muhammad, A.R., Asghar, A., Muhammad, A.M. & Mumtaz, H. (2010) Effect of fertilizer levels and plant densities on yield and protein contents of autumn planted maize. *Pakistan J. Agri. Sci.,* 47(3), 201-208.

Nandita, J., Vani, K.P., Praveen, R. and Siva Sankar, A. (2015) Effect of Nitrogen and Phosphorus Fertilizers on Growth and Yield of Quality Protein Maize (QPM). *Int. J. Sci. Res.,* (12):197-199.

Natr, L. (1992) Mineral nutrients an iniquitous stress factor for photosynthesis, *Photosynthetica*, 27:271–295.

Obi, C.O., Nnabude, P.C. and Onucha, E. (2005) Effects of kitchen waste compost and tillage on soil chemical properties and yield of Okra (*Abelmuschus esculentus*), *Soil Sci*., 15:69- 76.

Rana, K.S. and Choudhary, R.S. (2006) Productivity, nitrogen uptake and water use in maize-mungbean intercropping system as influenced by nitrogen levels under rainfed conditions. *Crop Res.*, 32(3): 306-308.

Reddiramer, Y. and Reddy, D.S. (2007) Yield, nutrient uptake and economics of hybrid maize as influenced by plant stand, levels and time of nitrogen application. *Crop Res.*, 33(3): 41-45.

Saeed, I.M., Abbasi, R. and Kazim, M. (2001) Response of maize (*Zea mays*) to nitrogen and phosphorus fertilization under agro-climatic condition of Rawalokol, Azad Jammu and Kaslim and Kashmir, *Pak. J. Biological Sci*., 4: 949-952.

Sahoo, S.C. and Mahapatra, P.K. (2007) Yield and economics of sweet corn (*Zea mays*) as affected by plant population and fertility levels. *Indian J. Agron*., 52(3): 239-242.

Sanjeev, K. & Bangarwa, A.S. (1997) Yield and yield components of winter maize (*Zea mays* L.) as influenced by plant density and nitrogen levels. *Agricultural Science Digest*. 17:181–184.

Shrivastava, V.K. and Sinha, N.K. (1992) Response of maize (*Zea mays* L.) and wheat (*Triticum aestivum)* to azotobacter inoculation and fertilizer application. *Indian J. Agron.*, 37 (2): 356 – 357.

Singh, A.K., Singh, G.R. and Dixit, R.S. (1997) Influence of plant population and moisture regimes on nutrient uptake and quality of winter maize (*Zea mays*). *Indian J. Agron*., 42(1): 107-111.

Singh, D., Tyagi, R.C., Hooda, I.S. and Verma, O.P.S. (1997) Influence of plant population, irrigation and nitrogen levels on the growth of spring maize. Haryana J. Agron, 13:54-58.

Singh, D.P., Rana, N.S. and Singh, R.P. (2000) Growth and yield of winter maize (*Zea mays* L.) influenced by intercrops and nitrogen application. *Indian Journal of Agronomy*, 45(3):515–519.

Subbiah, B.Y. and Asija, G.L. (1956) A rapid procedure for the estimation of available nitrogen in soils. *Curr. Sci*., 25: 259-260.