*Forage Res.,* **45** (2) : pp. 128-132 (2019) **http://forageresearch.in**

# GROWTH, YIELD AND ECONOMICS OF FODDER MAIZE (*ZEA MAYS*) AS INFLUENCED BY PLANT DENSITY AND FERTILITY LEVELS

**D. J. SUBRAHMANYA, RAKESH KUMAR*, P. S. PYATI, HARDEV RAM, R. K. MEENA AND AKANKSHA TAMTA**

ICAR- National Dairy Research Institute,
Karnal-132001, Haryana (India)
**(e-mail : drdudi_rk@rediffmail.com)*
**(Received : 29 August 2019; Accepted : 15 September 2019)**

## SUMMARY

An experiment consisting of four plant density (45, 60, 75 and 90 kg/ha seed rate) and five fertilizer levels (0, 50, 75, 100 and 125 % RDF) was laid out in split plot design to find out the growth and yield of fodder maize (*Zea mays* L.) under varying plant density and nutrient management. Green fodder yield and dry matter yield was significantly higher in case of 60 kg/ha seed rate (543.32 and 121.03 q/ha, respectively) and 125% RDF application (637 and 140.98 q/ha, respectively). Significantly higher growth parameters *viz.,* plant height (249.62 and 280.92 cm), leaf length (101.60 and 118.10 cm), leaf width (7.46 and 9.11 cm), number of leaves (14.44 and 17.13) *etc.* with seed rate (60kg/ha) and 125% RDF, respectively at harvest. At higher density beyond seed rate 60 kg/ha improvement in growth and yield was not significant. Nutrient uptake such as nitrogen (89.99 kg/ha) and phosphorus (39.85 kg/ha) significantly higher with 125% RDF application. Soil nitrogen and phosphorus status shown significant effect with respect varied seed rates and with respect to fertility levels, significantly higher soil N and P status were observed in 125% RDF application and 100 % RDF application was on par with it. Economics *viz.,* gross returns (Rs. 86555.4 and 98738.1) and net returns (Rs. 47038.3 and 59453.1) of fodder maize crop with 90 kg/ha seed rate and 125% RDF, respectively were significantly higher when compared to rest of the seed rates and recommended fertilizer levels whereas higher B: C ratio was obtained in case of 60 kg/ha and 125 % RDF.

**Key words :** Dry matter yield, fodder maize, green fodder yield, plant density and RDF

India being the largest milk producing country in the world has specific benefit in providing food security, nutritional security and economic returns to world's population. According to the Department of Animal Husbandry, Dairy & Fisheries, Government of India, Indian dairy sector is estimated to be worth Rs. 4,07,396 crore which produces around 18.5 % (Economic survey, 2015-16) of world's total milk production from 512.1 million livestock. Annual growth rate of this sector is around 4.1 % (Anonymous, 2014). Today India has emerged as the largest milk producer in the world with an annual production of 176 mt. White Revolution caused remarkable change with a five times increase in milk production of India. On the other hand low productivity of livestock is a distressful situation, which is mainly due to the poor feed and fodder availability. The supply of good quality fodder is a prerequisite for the success of dairy industry. At present, the country faces a net deficit of 35.6 % of green fodder, 10.95 % of dry crop residues and 44 % of concentrate feed ingredients (Anonymous, 2014). In our country total cropped area under cultivated forages is nearly 4.5 % (DARE, 2013).

Fodder maize (*Zea mays* L.) is one of the most important *kharif* forage crop next to sorghum in India and it occupies 0.9mha area. It is grown in more than 130 countries. It is of great importance for both human and animal feeding. Maize fodder has high digestibility and palatability. On an average, it contains 9-11% CP, 60-64% NDF, 38-41% ADF, 28-30% cellulose and 23-25% hemi-cellulose at milk to early-dough stage. It can be fed as green or dry and used to make excellent silage. Production potential of forage maize can be altered with changes in agronomic practices *viz.* plant density and nutrient management. Forage maize responds in a different way to plant densities under different environmental conditions and cultural practices which influence forage yield and quality. The association between maize forage yield/quality and plant density is not well recognized. Total dry matter content increases when plant density increases. Optimum plant density of maize may differ with grain

and forage production. Higher plant densities are favorable for forage crop than grain crops however; forage crops also have certain maximum limit of increase in plant population.

Fertilizer application is one of the principle factors that directly influence the fodder yield and quality. An adequate supply of nutrients at each growth stage is highly essential for good yield and quality of fodder maize. The essential nutrients such as nitrogen and phosphorus are important for plant growth, yield and quality. Fertilization is most important agronomic practices and therefore there are several studies conducted with different fertilizer levels suggests that optimum rate of fertilizer for forage maize cultivation depends on many variable factors such as environmental factors, management systems, soil fertility and ,management factors including plant density. Higher plant density may require more fertilizer. N and P fertilization of maize influences dry matter yield by influencing leaf area index, leaf area duration and photosynthetic efficiency. Some other researchers also reported that there were positive effects of nitrogen on dry matter yield and forage yield. Therefore, various doses of fertility are to be tested at different plant density. Keeping in view the above facts the present research has been planned to study the "Growth, yield and economics as influenced by plant density and nutrient management in fodder maize (*Zea mays*)"

## MATERIALS AND METHODS

The Field experiment was conducted at Agronomy Section, ICAR-National Dairy Research Institute, Karnal, Haryana during *Kharif* 2016. This zone receives rainfall from both southwest and northeast monsoons. Karnal faces extremes of both high and low temperature. During summer maximum temperature goes up to 45°C and in winter minimum temperature reaches near freezing point. The weekly mean meteorological data on the climate parameters for the experimental season are depicted in Fig 1 and 2. The experiment was laid out in the split plot design with four plant density (45, 60, 75 and 90 kg/ha seed rate) and five fertilizer levels (0, 50, 75, 100 and 125%RDF) and the plots were treated with nitrogen and phosphorus at the rate of 0 kg/ha, 60:30 kg/ha, 90:45 kg/ha, 120:60 kg/ha and 150:75 kg/ha, respectively as per percentage of RDF. The crop was sown in third week of April 2016 and maize variety J-1006 was used as test crop. The soil of the experimental field was sandy clay loam in texture with low in available nitrogen, medium in available phosphorus and high in available potassium with neutral pH. All the recommended agronomical practices were followed during growing period and soil analysis was done (AOAC, 2005). Nitrogen and phosphorus were applied at sowing time as per treatment in all the plots through urea and di ammonium phosphate (DAP), respectively. Crop was harvested at 65 DAS when 50% flowering was observed in the field. Biometric observations *viz.* plant height, leaf length, leaf width and numbers of leaves were recorded at 30 DAS and at harvest. Fresh fodder yield was recorded and samples were collected. Nutrient uptake by the crop was obtained by multiplying dry matter yield kg/ha and nutrient content (%). Statistical analysis was done using standard procedures of analysis of variance in split plot using OPSTAT software and statistical mean differences were found by Fisher's protected least significant difference test at $P<0.05$.

## RESULTS AND DISCUSSION

### Growth and yield

The plant height (Table 1) of the fodder maize at harvest increased significantly with the seed rate 60 kg/ha over seed rate of 45 kg/ha, with further increase in seed rate up to 90 kg/ha the differences in the plant height were statistically at par with each other at both stages. The results are in conformity with the findings of Joshi and Kumar (2007). Hada *et al*. (2016) also observed that seed rate of 60 kg/ha registered significantly highest plant height over seed rate 45 kg/ha. The plant height of the fodder maize at harvest increased significantly with the application of 125 % RDF over rest of the nutrient levels. Similar findings were also observed by Dadarwal *et al.* (2009) who reported that application of 100, 125 and 150 % of recommended dose of NPK (120: 40: 30 kg/ha) resulted in significant improvement in plant height of baby corn. Plant height of fodder maize at harvest was increased by 32.33%, 46.94%, 60.78% and 72.00% with increase in nitrogen application to 50%, 100% and 125 % RDF as compared to control treatment.

The leaf length (Table 1) of the fodder maize at harvest (101.60 cm) increased significantly with the seed rate 60 kg/ha, with further increase in seed rate the differences among leaf length at harvest were statistically at par with each other. The results are in conformity with the findings of Mahdi *et al.* (2012).

TABLE 1
Biometric observations, green fodder yield and dry matter yield of Fodder maize at harvest as influenced by varying seed rates and fertility levels.

| Treatments | Plant height (cm) | Leaf length (cm) | Leaf width (cm) | Number of leaves | Green fodder yield (q/ha) | Dry matter yield (q/ha) |
|---|---|---|---|---|---|---|
| **Seed rates** | | | | | | |
| 45 | 200.00 | 85.82 | 5.88 | 12.09 | 453.86 | 101.50 |
| 60 | 239.62 | 101.60 | 7.46 | 14.44 | 543.32 | 121.03 |
| 75 | 243.82 | 103.28 | 7.62 | 14.82 | 552.89 | 123.10 |
| 90 | 246.73 | 104.45 | 7.74 | 15.01 | 559.49 | 125.08 |
| S. Em± | 13.21 | 5.27 | 0.53 | 0.82 | 30.03 | 6.81 |
| C. D. (P=0.05) | 32.32 | 12.90 | 1.29 | 2.01 | 73.47 | 16.67 |
| **Nutrient levels** | | | | | | |
| 0 % RDF | 163.32 | 71.16 | 4.41 | 9.73 | 370.50 | 83.37 |
| 50 % RDF | 216.13 | 92.23 | 6.51 | 13.10 | 490.11 | 109.70 |
| 75 % RDF | 239.99 | 101.74 | 7.48 | 14.59 | 540.18 | 121.55 |
| 100 % RDF | 262.43 | 110.71 | 8.36 | 15.92 | 595.16 | 132.79 |
| 125 % RDF | 280.92 | 118.10 | 9.11 | 17.13 | 637.00 | 140.98 |
| S. Em± | 7.67 | 3.06 | 0.31 | 0.49 | 17.39 | 3.99 |
| C. D. (P=0.05) | 15.63 | 6.23 | 0.62 | 1.01 | 35.42 | 8.13 |

The leaf length of the fodder maize at harvest increased significantly with the application of 125% RDF over control. Leaf length was 65.96% more with 125% of RDF than control at harvesting, respectively. These results are supported by the findings of Thavaprakash and Velayudham (2009), who also reported increase in leaf length and leaf width of maize plant with decrease in plant density. At harvest, maximum leaf width of 3.56 cm and 7.46 cm were observed in 60 kg/ha seed rate with significant difference. The leaf width of the fodder maize at harvest increased significantly with the application of 125 % RDF over control, maximum leaf width of 9.11 cm was observed at harvest at 125% RDF. These results were in conformity with the findings of Valadabadi *et al.* (2010) who observed that the inorganic nitrogen treatments significantly affected leaf area index, relative growth rate and crop growth rate.

TABLE 2
Nutrient uptake and economics of Fodder maize at harvest as influenced by varying seed rates and fertility levels

| Treatments | Nitrogen uptake (kg/ha) | Phosphorus uptake (kg/ha) | Soil nitrogen status (kg/ha) | Soil Phosphorus status (kg/ha) | Cost of cultivation (kg/ha) | Net returns (Rs./ha) | B : C ratio |
|---|---|---|---|---|---|---|---|
| **Seed rates (kg/ha)** | | | | | | | |
| 45 | 63.80 | 30.20 | 196.30 | 16.63 | 33432.0 | 32915.5 | 0.98 |
| 60 | 72.08 | 32.08 | 187.48 | 15.75 | 34182.0 | 46036.4 | 1.35 |
| 75 | 68.74 | 28.11 | 185.23 | 15.52 | 34932.0 | 46765.8 | 1.34 |
| 90 | 68.65 | 27.53 | 184.89 | 15.49 | 35682.0 | 47038.3 | 1.32 |
| S. Em± | 7.34 | 5.28 | 2.37 | 0.24 | | | |
| C. D. (P=0.05) | 17.95 | 12.9 | 5.80 | 0.58 | | | |
| **Nutrient levels (kg/ha)** | | | | | | | |
| 0% RDF | 42.92 | 16.92 | 183.96 | 15.40 | 33625.0 | 19802.5 | 0.59 |
| 50% RDF | 59.48 | 25.67 | 186.22 | 15.62 | 34325.0 | 37641.9 | 1.10 |
| 75% RDF | 70.09 | 30.06 | 189.20 | 15.92 | 34605.0 | 45742.9 | 1.32 |
| 100% RDF | 79.10 | 34.90 | 190.75 | 16.08 | 34945.0 | 53304.7 | 1.53 |
| 125% RDF | 89.99 | 39.85 | 192.24 | 16.22 | 35285.0 | 59453.1 | 1.68 |
| S. Em± | 2.91 | 1.91 | 0.90 | 0.09 | | | |
| C. D. (P=0.05) | 5.93 | 3.89 | 1.84 | 0.18 | | | |

RDF : Recommended Dose of Fertilizer.

The number of leaves (Table 1) of the fodder maize at harvest increased significantly up to the seed rate 60 kg/ha over seed rate of 45 kg/ha. With further seed rate number of leaves increased but the differences were statistically at par with each other. However, Turgut *et al.* (2005) and Saruhan and Sireli (2005) reported that number of leaves significantly decreased with increasing plant density after a certain population in forage maize. The number of leaves of the fodder maize at harvest increased significantly with the application of 125 % RDF over control, maximum number of leaves (17.13) at harvest under 125% RDF. Number of leaves was increased by 82.68% and 76.05% with increasing nutrient level at harvesting, respectively. However, Saruhan and Sireli (2005) reported that nitrogen fertilizer did not affect significantly the number of leaves per plant of maize.

The green fodder yield (Table 1) at harvesting was influenced by application of both plant density and nutrient management. There was a significant effect on green fodder yield of the fodder maize plants at harvest up to seed rate 60 kg/ha over seed rate of 45 kg/ha, with further increase in seed rate up to 90 kg/ha, the differences in the green fodder yield was statistically at par with each other. Similar results were found by Hada *et al*. (2016). The green fodder yield of the fodder maize increased significantly with the application of 125 % RDF over control, maximum green fodder yield about 637.0 q/ha was observed at 125% RDF. Yield of fodder maize increased by 32.28, 45.79, 60.63 and 71.92% with increase in fertility levels to 50%, 75%, 100% and 125% RDF as compared to control.the results were in line with Kumar *et al.* (2015).

There was a significant effect on dry matter yield of the fodder maize plants at harvest up to seed rate 60 kg/ha, with increase in seed rate after 60 kg/ha the dry matter yield was increased but the difference in the dry matter yield was statistically at par. Increase in dry matter yield at higher seed rate was mainly due to more plant density per unit area *viz.,* higher plant height, higher leaf area and more number of functional leaves per unit area. Increase in dry matter yield with increased seed rate has also been reported by Valadabadi and Farhani (2010) and Mahdi *et al.* (2012). The dry matter yield of the fodder maize at harvest increased significantly with the application of 125 % RDF over control, dry matter yield of 140.98 q/ha was observed at harvest. Dry matter yield was increased by 69.10% from control to 125% RDF treatment. Higher dry matter production could be attributed to the production of taller plants with maximum photosynthetic area that provided the way for production of more dry matter. Patel *et al*. (2006) and reported similar findings.

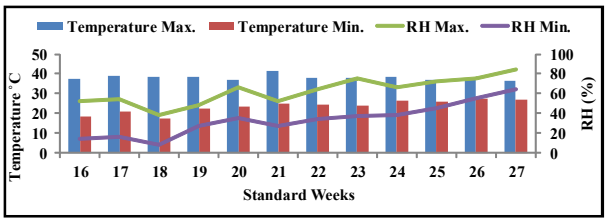


Fig. 1. Variation in temperature and relative humidity during crop season.

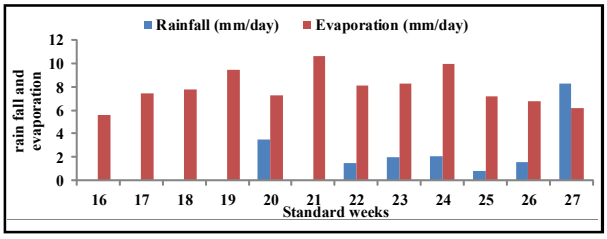


Fig. 2. Rainfall and evapotranspiration during crop season.

**Nutrient uptake**

The nitrogen uptake was improved up to seed rate of 60 kg/ha after that there was decrease in nitrogen uptake though differences were statistically at par. Fertilizer application showed significant increase in nitrogen uptake up to the level of 125% RDF with maximum uptake (89.99 kg/ha) found at 125% RDF. Phosphorus uptake was improved up to seed rate of 60 kg/ha after that there was decrease in phosphorus uptake though differences were statistically at par. Fertilizer application showed significant increase in phosphorus uptake up to the level of 125% RDF with maximum uptake (39.85 kg/ha) found at 125% RDF. Owla *et al.* (2015) found significant increase in nitrogen and phosphorus uptake by quality protein maize was observed by raising the nutrient level up to 150 kg N + 60 kg $P_2O_5$/ha and the application of entire quantity of NP through fertilizers resulted in the NP uptake by the crop.

When seed rate was increased from 45 kg/ha to 60 kg/ha soil nitrogen content was also decreased significantly from 196.30 kg/ha to 180.47 kg/ha, with further increase in seed rate soil nitrogen content was decreased but it was statistically at par with each other. When seed rate was increased from 45 kg/ha to 60 kg/ha soil phosphorus content was also decreased significantly from 16.63 kg/ha to 15.75 kg/ha. With further increase in seed rate soil phosphorus content was decreased but it was statistically at par with each other. With the increase in fertilizer levels from 0%

RDF to 125% RDF soil nitrogen content increased significantly from 183.96 to 192.24 kg/ha. Soil phosphorus content was increased significantly from 15.40 to 16.22 kg/ha as nutrient levels was increased from 0% RDF to 125% RDF. The findings are in line with Mahdi *et al.* (2012).

## ECONOMICS

The mean cost cultivation was Rs. 33432.0 in 45 kg/ha seed rate. With the increase in plant density the cost of cultivation was also increased, maximum cost of cultivation of Rs. 35682.0 per ha was observed at 90 kg/ha seed rate. The net returns was Rs. 32915.5 per ha in 45 kg/ha seed rate, with the increasing in plant density the net returns (Rs./ha) was also increased and maximum net returns of 47038.3 was observed at 90 kg/ha seed rate. The benefit cost ratio was 0.98 in 45 kg/ha seed rate, with the increasing in plant density the B: C ratio was increased up to 1.35 in 60 kg/ha seed rate. With further increase in seed rate the constant B: C ratio was observed. This might be due to higher productivity and higher economic returns with higher plant population up to 60 kg/ha. Gollar (1997) reported that higher plant density also resulted in higher B: C ratio due to significant enhancement in net income. The mean cost of cultivation was Rs. 33625.0 in 0% RDF with the increasing in the nutrient levels and maximum cost of cultivation of 35285.0 was observed at 125% RDF. The net returns (Rs./ha) was 19802.50 in 0% RDF with the increasing in the fertilizer levels net returns (Rs./ha) was also increased the maximum net returns (Rs./ha) of 59453.1 was observed at 125% RDF. The benefit cost ratio was 0.59 in 0% RDF. With the increasing in the fertilizer levels the B: C ratio was also increased and maximum B: C ratio of 1.68 was observed at 125% RDF. This might be due to higher productivity and higher economic returns with higher level of nutrient application.

## CONCLUSIONS

From the findings of the experiment, it may be concluded that application of 60 kg/ha seed rate with 125% RDF gave better growth and yield. Use of optimum seed rate and balanced dose of fertilizers is necessary for better growth and yield of fodder maize.

## REFERENCES

Anonymous. 2014 : IGFRI Vision, 2050. ICAR-Indian Grassland and Fodder Research Institute, Jhansi.

AOAC, 2005 : Official methods of analysis, 18th revised. Astionsocia of official analytical chemists, Arlington, Virginia, USA.

Dadarwal, R. S., Jain, N. K. and Singh, D. 2009 : Integrated nutrient management in baby corn (*Zea mays*). *Ind. J. Agric. Sci.* **79** : 1023-1025.

DARE-2013 : Department of Agricultural Research and Education, Govt. of India.

Gollar, R. G. 1996 : Plant density, irrigation at critical stages and staggered and simultaneous planting of crops in *rabi* maize. Thesis, UASD, Dharwad.

Hada, N., Wasnik, V. K., Bhadauria, S. S. and Singh, K. V. 2016 : Influence of balanced nutrition, seed rate and plant geometry on fodder maize in South-Eastern Rajasthan. *Range Manag. and Agro Forestry* **37** : 243-247.

Joshi, Y. P. and Kumar, K. 2007 : Effect of nitrogen levels and seed rates on growth, yield and quality of fodder maize variety 'African tall'. *Forage Res.,* **33** : 171-173.

Kumar, R., Singh, M., Tomar, S. K., Meena, B. S. and Rathore, D. K. 2015 : Productivity and nutritive parameters of fodder maize under varying plant density and fertility levels for improved animal productivity ICAR- National Dairy Research Institute. *Ind. J. Animal Res*. 367-672. pp.

Mahdi, S. S., Hasan, B. and Singh, L. 2012 : Influence of seed rate, nitrogen and zinc on fodder maize (*Zea mays*) in temperate conditions of western Himalayas. *Ind. J. Agron.* **57** : 85-88.

Owla, M. L., Nepaaia, V., Chouhan, G. S. and Dilip, S. 2015 : Effect of fertility levels, nutrient sources and weed control on weed dynamics and yield of quality protein maize and relative nitrogen and phosphorus uptake. *Ind. J. Agron.* **60** : 267-272.

Patel, J. B., Patel, V. J. and Patel, J. R. 2006 : Influence of different methods of irrigation and nitrogen levels on crop growth rate and yield of maize (*Zea mays* L.) *Ind. J. Crop Sci.* **1** : 175-177.

Saruhan, V. and Sireli, H. D., 2005 : An investegate on the effect of plant densities and nitrogen doses on ear, stem and leaf yields of maize (*Zea Mays* L.). *Journal of Agriculture* **9** : 45-53.

Thavaprakaash, N. and Velayudham, K. 2009 : Influence of crop geometry, intercropping system and INM practices on productivity of baby corn based intercropping. *Mysore J. Agric. Sci*. **43** : 686-695.

Turgut, I., Duman, A., Bilgili, U. and Acikgoz, E. 2005 : Alternate row spacing and plant density effects on forage and drymatter yield of corn hybrids (*Zea mays* L.). *J. Agron.* **191** : 146-151.

Valadabadi, Farahani, H. A. and Alireza, H. 2010 : Effects of planting density and pattern on physiological growth indices in maize (*Zea mays* L.) under nitrogenous fertilizer application. *J. Agric. Extension and Rural Development* **2** : 40-47.