Influence of Plant Densities and Nitrogen Levels on the Performance of Popcorn Hybrid

Y. Siva Lakshmi¹*, D. Sreelatha² and T. Pradeep³

¹College of Agricultural Engineering, Kandi, Sangareddy, India.
²Maize Research Centre (Professor Jayashankar Telangana State Agricultural University), Agricultural Research Institute, Rajendranagar, Hyderabad, Telangana, India.
³Seed Research and Technology Centre (Professor Jayashankar Telangana State Agricultural University), Rajendranagar, Hyderabad, Telangana, India.

Authors’ contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2020/v39i4231125

ABSTRACT

A field experiment was conducted at the Maize Research Centre, Agricultural Research Institute (ARI), Rajendranagar, Hyderabad during the rabid seasons (15 October to 15 January) for two years to study the effect of plant densities and nitrogen levels on growth parameters, yield characteristics, yield and economics of the newly published popcorn hybrid BPCH-6 by Professor Jayashankar Telangana State Agricultural University (Previously Acharya NG Ranga Agricultural University). Three plant densities (P₁=1,11,111 ha⁻¹ (60 x 15 cm), P₂=1,11,111 ha⁻¹ (45 x 20 cm) and P₃=83,333 ha⁻¹ (60 x 20 cm)) and four levels of nitrogen (N₁=80 kg ha⁻¹, N₂=120 kg ha⁻¹, N₃=160 kg ha⁻¹ and N₄=200 kg ha⁻¹) were taken in a randomised block configuration with three repeated factorial principles. Significantly higher plant height with a population of 1, 11,111 ha⁻¹ (45x20 cm), significantly higher leaf area index with a population of 1, 11,111 ha⁻¹ (60x15 cm) and significantly higher dry matter production (g plant⁻¹) with a population of 83,333 plants ha⁻¹ (60x20 cm) was observed as per pooled mean over two years. Yield attributes like cob girth, number of rows cob⁻¹...
and 100 seed weight were not influenced significantly whereas cob length and number of seeds row\(^{-1}\) were significantly superior with optimum plant density of 83,333 ha\(^{-1}\). A plant density of 1, 11,111 ha\(^{-1}\) (60x15 cm). recorded significantly higher cob, grain fodder yields. When a population of 1, 11,111 plants ha\(^{-1}\) (60x15 cm) was maintained, gross and net returns and profit cost ratios were higher. The use of 200 kg of nitrogen ha\(^{-1}\) resulted in slightly higher growth parameters, yield characteristics and yield, but it was equal to 160 kg of N ha\(^{-1}\) and both were greater than 120 and 80 kg of N ha\(^{-1}\). Application of 160 Kg N ha\(^{-1}\) recorded higher gross and net returns and benefit cost ratio compared to 200 Kg N ha\(^{-1}\).

**Keywords:** Popcorn; rabi; plant densities; nitrogen levels; growth parameters; yield attributes; yield; economics.

1. **INTRODUCTION**

One of the essential cereals in India is maize (Zea mays L.). It is predominantly used in India as poultry feed (49%), animal feed (12%), and 25% as food in various types [1]. Popcorn (Zea mays variety everta) is a specialty type of maize that produces exceptional popping consistency, which when heated implies expansion in kernel volume. In many peri-urban areas, it is gaining importance as a popular nutritious snack food. There are currently four popcorn varieties available for commercial cultivation in India, such as Amber popcorn, VL popcorn, Jawahar popcorn and Pearl popcorn [2,3]. Maize Research Centre, Professor Jayashankar Telangana State Agricultural University, Hyderabad, Telangana, India, tried to grow hybrid in popcorn for the first time as the yield of hybrid is superior compared to varieties. Consequently, Professor Jayashankar Telangana State Agricultural University (formerly Acharya NG Ranga Agricultural University) published the first popcorn hybrid BPCH-6 at national level. Agronomic assessment must be done before the publication of any hybrid. Among the various agronomic practices, plant density and fertilizer are the most important factors which greatly influence the potential yield realisation from any crop [4]. Popcorn yield is significantly influenced not only by genetic potential but also by different cultural practices as reported by Halluer [5], Babic and Pajic [6] and Ziegler et al. [7]. Though plant density and fertiliser requirement of grain maize has been standardised by many authors the recommended plant density and nitrogen dose for the normal maize hybrids may not be applicable for the popcorn hybrid [8] and [9]. The current study on "Performance of popcorn hybrids at varying plant densities and nitrogen levels during rabi" was taken up at the Maize Research Centre, Agricultural Research Institute (ARI), Rajendranagar, Hyderabad, Telangana, India, as part of agronomic assessment and also maintaining the significance of popcorn popularisation in a commercial way in peri-urban areas.

2. **MATERIALS AND METHODS**

The experiment was conducted at the Maize Research Centre, Agricultural Research Institute, Rajendranagar, Hyderabad for two years during rabi (From October 15\(^{th}\) to January 15\(^{th}\)). The altitude, latitude and longitude of the experimental site is 542.3 m above mean sea level, 17\(^{o}\) 19’ N and 78\(^{o}\) 24’ E respectively which is a part of Southern Telangana agro-climatic zone of Telangana (Previously part of Andhra Pradesh). The soil of the experimental field was clay loam, slightly alkaline (pH 7.8) with low organic carbon (0.38 %) and available nitrogen (195.3 kg ha\(^{-1}\)), medium in available phosphorous (30.23 kg ha\(^{-1}\)) and high in available potassium (156.7 kg ha\(^{-1}\)). The experiment was laid out in randomized block design in factorial with three replications. Treatments were three plant densities (P\(_{1}\)–1,111 ha\(^{-1}\) (45 x 20 cm), P\(_{2}\)–1,111 ha\(^{-1}\) (60 x 15 cm) and P\(_{3}\)–83,333 ha\(^{-1}\) (60 x 20 cm) and four nitrogen levels (N\(_{1}\)–80 kg ha\(^{-1}\), N\(_{2}\)–120 kg ha\(^{-1}\), N\(_{3}\)–160 kg ha\(^{-1}\) and N\(_{4}\)–200 kg ha\(^{-1}\). BPCH-6 hybrid of Popcorn was used in the experiment. It is suitable for both kharif and rabi cultivation in Telangana (Previously part of Andhra Pradesh). The crop was sown on 20\(^{th}\) October and harvested on 12\(^{th}\) January. Seeds were dibbled at a depth of 3–4 cm to maintain the desired plant population. Irrigation was given to ensure proper and uniform germination. Thinning was performed within 15 days after germination to allow only one healthy seedling per hill. The nitrogen fertilizer was applied according to the treatments viz., 80, 120, 160 and 200 kg ha\(^{-1}\) in the form of solid fertilizer urea
after calculating the proportion of nitrogen applied through solid fertilizer Diammonium Phosphate (DAP). Phosphorus @ 60 kg ha\(^{-1}\) as DAP and Potash @ 50 kg ha\(^{-1}\) as solid fertilizer Muriate of Potash (MOP) were applied. Entire phosphorus and potash were applied as basal. Nitrogen fertilizer was applied in three splits as per schedule i.e., 1/13\(^{rd}\) N as basal, 1/3\(^{rd}\) N at 30 days after sowing (DAS) and remaining 1/3\(^{rd}\) N at 60 DAS. Standard agronomic practices recommended by Professor Jayashankar Telangana State Agricultural University were followed to raise a healthy and uniform crop. The cobs from border rows of each plot were harvested separately and later the cobs from the net plot were harvested to reduce the border effect of neighboring treatments. Fischer’s method of analysis of variance technique by Gomez and Gomez [10] was adapted for interpretation of data. The levels of significance used in ‘F’ and ‘t’ test were P=0.05 and 0.01 and critical values were calculated wherever the ‘F’ test was significant.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Growth parameters like plant height at harvest (cm), Leaf area index (LAI) at harvest and dry matter production (g) were influenced significantly by both plant densities and nitrogen levels in both the years. Pooled mean over two years indicated that, significant increase in plant height was observed with a plant population of 83,333 plants ha\(^{-1}\) (166 cm) compared to 1,11,111 plants ha\(^{-1}\) (184 cm). Within the same plant population of 1,11,111 plants ha\(^{-1}\) also, narrow row spacing of 45x20 cm recorded significantly higher plant height (184 cm) compared to wider row spacing of 60 x 15 cm (176 cm) (Table 1). Greater interplant competition at higher plant densities might have reduced the amount of light availability to the individual plant and hence the plant tended to grow taller in search of sunlight. Similar kind of results in popcorn were already noticed by Ülger [11], Güzübenli, et al. [23], Khalifa et al. [24] and Sezer and Yanbeyi [25].

Interaction effect showed that significantly higher plant height and leaf area index was with 1,11,111 plants ha\(^{-1}\) and at 200 kg N ha\(^{-1}\) but it was on par with 160 kg N ha\(^{-1}\) whereas significantly higher dry matter production was with 83,333 plants ha\(^{-1}\) and at 200 kg N ha\(^{-1}\) but it was on par with 160 kg N ha\(^{-1}\).

3.2 Yield Attributes

Cob girth, number of rows cob\(^{-1}\) and 100 seed weight were not significantly influenced either by plant densities or nitrogen levels except with cob girth which was significantly influenced only by plant densities (Table 2). Most of them being genetic characters, external factors might not have shown the significant influence. Whereas, densities and nitrogen levels have showed significant influence on cob length and number of
seeds row\(^{-1}\) (Table 3). Optimum plant density of 83,333 ha\(^{-1}\) with wider row spacing of 60x20 cm recorded significantly greater cob length (20.8 cm) and number of seeds row\(^{-1}\) (34.8) compared to high plant density of 1,11,111 ha\(^{-1}\) with narrow row spacing of 45x20 cm (19.0 cm and 31.0 respectively). The decrease in cob length and number of seeds row\(^{-1}\) with high plant population beyond optimum might be as a result of interplant competition for light, nutrients and water. Williams et al., [26] also reported that photosynthetic efficiency and growth in maize were strongly related to the effect of canopy architecture on the vertical distribution of light within the canopy. The results are in accordance with the findings of Sade and Çalis, [27] in popcorn.

Application of nitrogen at 200 kg ha\(^{-1}\) produced significantly higher cob length (20.4 cm) and number of seeds row\(^{-1}\) (33.8) but was on par with 160 kg ha\(^{-1}\) (20.6 cm and 33.6 respectively) and both were significantly superior over the rest of the treatments (Table 3). Nitrogen is a primary nutrient which shows significant influence on the plant productivity. Maize being an exhaustive crop, might have responded well to increased nitrogen application. And also, better vegetative growth in terms of greater plant height, LAI and dry matter production might have led to increased yield attributing characters. Similar kind of response in popcorn was reported by Sabri Gokmen et al. [28].

Interaction effect showed that significantly higher cob length and number of seeds row\(^{-1}\) were with 83,333 plants ha\(^{-1}\) and at 200 kg N ha\(^{-1}\) but were on par with 160 kg N ha\(^{-1}\).

3.3 Yield

Cob, grain and fodder yields (t ha\(^{-1}\)) of popcorn were significantly influenced by both plant densities and nitrogen levels (Table 3). Pooled data over two years indicated that, a plant population of 1,11,111 plants ha\(^{-1}\) (5.6 t ha\(^{-1}\)) showed significantly higher grain yield compared to 83,333 ha\(^{-1}\) (4.4 t ha\(^{-1}\)). Higher yield attributes in optimum plant population of 83,333 ha\(^{-1}\) did not record higher yield as loss of plants in lower plant density was not compensated by increased yield attributes whereas greater number of plants have compensated the reduction in yield attributes. Sahoo and Mahapatra [29] and Kumar [30] also reported similar results. Even with the same plant population of 1,11,111 plants ha\(^{-1}\), wider row spacing of 60x15cm recorded significantly higher grain yield (5.6 t ha\(^{-1}\)) whereas narrow row spacing of 45 x 20 cm recorded significantly lower grain yield (4.9 t ha\(^{-1}\)) (Table 3). Pooled mean over two years indicated that the per cent increase in grain yield at 1,11,111 plants ha\(^{-1}\) (60x15 cm) over 83,333 plants ha\(^{-1}\) (60x20 cm) and 1,11,111 plants ha\(^{-1}\) (45x20 cm) was 21.4 and 12.5 respectively. Cob and fodder yield also followed similar trend (Table 3).

Fig. 1. Experimental site map
Table 1. Plant height (cm) at harvest, leaf area index (LAI) (%) at harvest and dry matter production (g plant\(^{-1}\)) of popcorn hybrid as influenced by plant densities and nitrogen levels.

| Treatments | Plant height (cm) at harvest | Leaf area index (LAI) (%) at harvest | Dry matter production (g plant\(^{-1}\)) |
|------------|-----------------------------|-------------------------------------|--------------------------------------|
|            | 80 Kg N ha\(^{-1}\)        | 120 Kg N ha\(^{-1}\)                | 160 Kg N ha\(^{-1}\)                | 200 Kg N ha\(^{-1}\)                | Mean   | 80 Kg N ha\(^{-1}\) | 120 Kg N ha\(^{-1}\) | 160 Kg N ha\(^{-1}\) | 200 Kg N ha\(^{-1}\) | Mean   |
| 1,11,111   | 169                         | 176                                 | 195                                 | 197                                 | 184    | 3.6                     | 4.4                     | 5.0                     | 5.0                     | 4.5    | 60.6                     | 65.1                     | 72.1                     | 74.3                     | 68.0    |
| Plants ha\(^{-1}\) (45x20 cm) |               |                                     |                                     |                                     |        |                         |                         |                         |                         |        |                         |                         |                         |                         |        |
| 1,11,111   | 164                         | 169                                 | 184                                 | 188                                 | 176    | 4.1                     | 4.9                     | 5.7                     | 5.7                     | 5.1    | 65.2                     | 72.1                     | 80.1                     | 79.6                     | 73.5    |
| Plants ha\(^{-1}\) (60x15 cm) |               |                                     |                                     |                                     |        |                         |                         |                         |                         |        |                         |                         |                         |                         |        |
| 83,333     | 161                         | 167                                 | 169                                 | 170                                 | 166    | 3.5                     | 3.9                     | 4.5                     | 4.1                     | 4.1    | 67.0                     | 74.3                     | 86.7                     | 88.2                     | 79.1    |
| Plants ha\(^{-1}\) (60x20 cm) |               |                                     |                                     |                                     |        |                         |                         |                         |                         |        |                         |                         |                         |                         |        |
| Mean       | 165                         | 171                                 | 183                                 | 185                                 | 3.7    | 4.4                     | 5.1                     | 5.1                     |                         |        | 64.3                     | 69.6                     | 79.6                     | 80.7                     |
| S. Em +   | CD (P=0.05)                 | S. Em + CD (P=0.05)                 | S. Em + CD (P=0.05)                 |          |        |                         |                         |                         |                         |        |                         |                         |                         |                         |        |
| P          | 2.5                        | 6                                   | 0.02                                | 0.04                                |        | 2.5                     | 7.1                     |                         |                         |        |
| N          | 2.0                        | 5                                   | 0.02                                | 0.04                                |        | 2.2                     | 5.0                     |                         |                         |        |
| P x N      | 4.0                        | 11                                  | 0.03                                | 0.08                                |        | 3.1                     | 10.2                    |                         |                         |        |

Table 2. Cob girth (cm), number of rows cob\(^{-1}\) and 100 seed weight (g) of popcorn hybrid as influenced by plant densities and nitrogen levels (pooled mean over 2 years)

| Treatment | Cob girth (cm) | Number of rows cob\(^{-1}\) | 100 Seed weight(g) |
|-----------|----------------|-------------------------------|---------------------|
| Plant densities (plants ha\(^{-1}\)) | | | |
| 1,11,111 (45x20 cm) | 9.7 | 13.4 | 13.1 |
| 1,11,111 (60x15 cm) | 10.1 | 13.4 | 13.3 |
| 83,333 (60x20 cm) | 10.6 | 13.7 | 13.5 |
| S. Em + CD (P=0.05) | 0.1 | 0.3 | 0.2 |
| Nitrogen levels (kg N ha\(^{-1}\)) | | | |
| 80 | 9.6 | 13.4 | 13.3 |
| 120 | 9.9 | 13.4 | 13.3 |
| 160 | 10.5 | 13.5 | 13.5 |
| 200 | 10.6 | 13.6 | 13.6 |
| S. Em + CD (P=0.05) | 0.1 | 0.2 | 0.2 |
| Interaction | NS | NS | NS |
Table 3. Cob length (cm), number of seeds row⁻¹, cob yield (t ha⁻¹), grain yield (t ha⁻¹) and fodder yield (t ha⁻¹) of popcorn hybrid as influenced by plant densities and nitrogen levels

| Treatments | Cob length (cm) | Number of seeds row⁻¹ | Cob yield (t ha⁻¹) | Grain yield (t ha⁻¹) | Fodder yield (t ha⁻¹) |
|------------|----------------|----------------------|-------------------|---------------------|----------------------|
|            | 80 Kg N ha⁻¹  | 120 Kg N ha⁻¹  | 160 Kg N ha⁻¹ | 200 Kg N ha⁻¹ | Mean N ha⁻¹ | 80 Kg N ha⁻¹  | 120 Kg N ha⁻¹ | 160 Kg N ha⁻¹ | 200 Kg N ha⁻¹ | Mean N ha⁻¹ | 80 Kg N ha⁻¹  | 120 Kg N ha⁻¹ | 160 Kg N ha⁻¹ | 200 Kg N ha⁻¹ | Mean N ha⁻¹ |
| 1,11,111   | 18.5           | 18.6               | 19.5           | 19.0           | 29.8    | 30.1              | 31.6           | 31.7           | 31.0           | 4.5     | 4.8           | 5.9           | 6.0           | 5.3           | 4.1     | 4.7           | 5.3           | 5.4     |
| Plants ha⁻¹|               |                     |                |                |         |                   |                |                |                |           |             |               |               |               |           |             |               |           |
| (45x20 cm) | 19.5           | 19.7               | 20.8           | 20.1           | 32.0    | 32.8              | 33.4           | 33.9           | 33.0           | 5.3     | 5.8           | 6.9           | 6.9           | 6.2           | 5.0     | 5.3           | 6.0           | 6.0     |
| 1,11,111   | 20.0           | 20.2               | 21.6           | 21.3           | 33.6    | 33.9              | 35.7           | 36.8           | 35.8           | 4.1     | 4.6           | 5.1           | 5.0           | 4.7           | 4.2     | 5.1           | 4.9           | 4.4     |
| Plants ha⁻¹|               |                     |                |                |         |                   |                |                |                |           |             |               |               |               |           |             |               |           |
| (60x15 cm) | 19.3           | 19.5               | 20.6           | 20.4           | 31.8    | 32.3              | 33.6           | 33.8           | 4.6            | 5.1     | 6.0           | 6.0           | 4.2           | 4.7           | 5.5     | 5.4           | 5.1           | 5.6     |
| 83,333     | 19.3           | 19.5               | 20.6           | 20.4           | 31.8    | 32.3              | 33.6           | 33.8           | 4.6            | 5.1     | 6.0           | 6.0           | 4.2           | 4.7           | 5.5     | 5.4           | 5.1           | 5.6     |
| Plants ha⁻¹|               |                     |                |                |         |                   |                |                |                |           |             |               |               |               |           |             |               |           |
| (60x20 cm) | 19.3           | 19.5               | 20.6           | 20.4           | 31.8    | 32.3              | 33.6           | 33.8           | 4.6            | 5.1     | 6.0           | 6.0           | 4.2           | 4.7           | 5.5     | 5.4           | 5.1           | 5.6     |
| Mean       | 19.3           | 19.5               | 20.6           | 20.4           | 31.8    | 32.3              | 33.6           | 33.8           | 4.6            | 5.1     | 6.0           | 6.0           | 4.2           | 4.7           | 5.5     | 5.4           | 5.1           | 5.6     |

| S. Em + CD (P=0.05) | S. Em + CD (P=0.05) | S. Em + CD (P=0.05) | S. Em + CD (P=0.05) | S. Em + CD (P=0.05) | S. Em + CD (P=0.05) | S. Em + CD (P=0.05) |
|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| P                   | 0.3                 | 0.6                 | 0.4                 | 1.2                 | 0.1                 | 0.3                 |
| N                   | 0.3                 | 0.7                 | 0.3                 | 1.0                 | 0.2                 | 0.4                 |
| P x N               | 0.5                 | 1.1                 | 0.8                 | 3.0                 | 0.2                 | 0.6                 |
3.4 Economics

Both plant densities and nitrogen levels influenced the cost of cultivation, gross and net returns and benefit cost ratio (Table 4).

Population of 1,11,111 plants ha⁻¹ recorded higher gross returns (₹ 1,71,550 ha⁻¹), net returns (₹ 1,28,718 ha⁻¹) and benefit cost ratio (3.01) compared to lower gross returns (₹ 1,31,850 ha⁻¹), net returns (₹ 91,018 ha⁻¹) and benefit cost ratio (2.23) with a population of 83,333 ha⁻¹.

Among the nitrogen levels, application of 160 kg ha⁻¹ resulted in higher gross returns (₹ 1,68,350 ha⁻¹), net returns (₹ 1,25,694 ha⁻¹) and benefit ratio of 2.95 compared to 200 kg ha⁻¹ (₹ 1,65,450 ha⁻¹, ₹ 1,21,812 ha⁻¹ and 2.80 respectively).

4. CONCLUSION

From the results, it can be concluded that, both Plant density and Nitrogen had major impact on performance of Popcorn. In the Southern Telangana Agroclimatic Zone of Telangana, India, a plant density of 1, 11,11 plants ha⁻¹ (60x15 cm) with 160 kg N ha⁻¹ is considered optimal for obtaining higher yields and net income for the Popcorn hybrid to be produced.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Meena BP, Meena VD, Dotaniya ML. Package of practices of speciality type corn: Popcorn; 2012.
2. Meena BP, Meena VD, Dotaniya ML. Packaging and practices of speciality type corn: Pop corn; 2016.
Available:https://www.researchgate.net/publication/305145700:127

---

Table 4. Cost of cultivation (₹ ha⁻¹), gross returns (₹ ha⁻¹), net returns (₹ ha⁻¹) and benefit cost ratio of popcorn hybrid as influenced by plant densities and nitrogen levels (mean over 2 years)

| Treatment                  | Cost of cultivation (₹ ha⁻¹) | Gross returns (₹ ha⁻¹) | Net returns (₹ ha⁻¹) | B:C ratio |
|----------------------------|-------------------------------|-----------------------|---------------------|-----------|
| Plant densities (plants ha⁻¹) |                               |                       |                     |           |
| 1,11,111 (45x20 cm)         | 42,832                        | 1,47,150              | 1,04,318            | 2.44      |
| 1,11,111 (60x15 cm)         | 42,832                        | 1,71,550              | 1,28,718            | 3.01      |
| 83,333 (45x20 cm)           | 40,832                        | 1,31,850              | 91,018              | 2.23      |
| Nitrogen levels (kg N ha⁻¹) |                               |                       |                     |           |
| 80                         | 40,694                        | 1,28,850              | 88,156              | 2.17      |
| 120                        | 41,676                        | 1,44,050              | 1,02,374            | 2.46      |
| 160                        | 42,656                        | 1,68,350              | 1,25,694            | 2.95      |
| 200                        | 43,638                        | 1,65,450              | 1,21,812            | 2.79      |

Cost of grain/kg = ₹ 30/-
Cost of fodder/kg = ₹ 0.5/-
15. Suryavanshi VP, Chavan BN, Jadhav KT, Pagar PA. Effect of spacing, nitrogen and phosphorus levels on growth, yield and economics of kharif maize. International Journal of Tropical Agriculture 2008;26(3–4):287–291.

16. Evans LT, Fischer RA. Yield potential: Its definition, measurement and significance, Crop sci. 1999;39:1544-1551.

17. Long SP, Zhu XG, Naidu S, Ort DR. Can improvement in photosynthesis increase crop yields? Plant Cell Environ. 2006; 29:315-330.

18. Amthor JS. Improvement of crop plants for industries end uses, ed. P. Ranalli (Dordrecht: Springer). 2007;27-58.

19. Bindhani A, Barik KC, Garnayak LM, Mahapatra PK. Nitrogen management in baby corn. Indian Journal of Agronomy. 2007;52(2):135–138.

20. Sepat S, Kumar A. N management in maize (Zea mays) under lifesaving and assured irrigation. Indian Journal of Agricultural Sciences. 2007;77(7):451–454.

21. Oktem A, Oktem AG, Emeklier HY. Effect of nitrogen on yield and some quality parameters of sweet corn. Communications in Soil Science and Plant Analysis. 2010;41(7):832–847.

22. Gozubeni H, Ulger AC, Ener O. The effects of different nitrogen doses on grain yield and yield-related characters of some maize genotypes grown as second-crop. (in Turkish) J. Agric. Fac. Ç.Ü. 2001; 16(2):39-48.

23. Khalifa MA, Shokr ES, El-Sseyyed Kl. Effect of nitrogen and plant population levels on the growth and yield of maize cultivars. J. Res. Punjab Agric. Univ. 1984;23(4):544-548.

24. Sezer I, Yanbeyi S. Plant density and nitrogen fertilizer effect on grain yield, yield components and some plant characters of pop corn in Çaramba Plain. Turkey 2. Field Corps Congree, 22-25 September 1997, Samsun, (in Turkish). 1997;128-133.

25. Williams WA, Loomis RS, Duncan WG, Dovert A, Nunez F. Canopy architecture at various population densities and the growth and grain of corn. Crop Science. 1998;8:303-308.

26. Sade B, Calis M, Erdemil Ekolojik Sartlananda, Oron Olarak Yetistirilen Cinmisir. Populasyonlannin. Ziraat fakoltesi Dergisi.1993;3(5):32-45.
28. Sabri Gokmen, Ozer Sencar, Mehmet Ali Sakin. Response of popcorn to Nitrogen rates and plant densities. Turk Journal of Agric For. 2001;25:15-23.

29. Sahoo, Mahapatra. Yield and economics of sweet corn (Zea mays) as affected by plant population and fertility levels. Indian Journal of Agronomy. 2007;52(3):239–242.

30. Kumar A. Productivity economics and nitrogen use efficiency of specialty corn (Zea mays L.) as influenced by planting density and nitrogen fertilization. Indian Journal of Agronomy 2008;53(4):306–09.

31. Kumar MA, Gali SK, Hebsur NS. Effect of different levels of NPK on growth and yield parameters of sweet corn. Karnataka Journal of Agriculture Science. 2007;20(1): 41–43.

32. Singh MK, Singh RN, Singh SP, Yadav MK, Singh VK. Integrated nutrient management for higher yield, quality and profitability of baby corn (Zea mays). Indian Journal of Agronomy. 2010;52(2): 100–104.

33. Nagy J. The Effect of fertilization on the yield of maize with and without irrigation. Cereal Research Communications. 1997; 25:69-76.