African Journal of Agricultural Research Vol. 7(46), pp. 6158-6166, 5 December, 2012
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR12.557
ISSN 1991-637X ©2012 Academic Journals

Full Length Research Paper

Response of sweet corn hybrid to varying plant densities and nitrogen levels

P. Spandana Bhatt

Department of Agronomy, College of Agriculture, Acharya N.G. Ranga Agricultural University, Hyderabad -500 030, Andhra Pradesh, India.
Agricultural Research Institute, Acharya N.G. Ranga Agricultural University, Hyderabad -500 030, Andhra Pradesh, India. E- mail: spandana9119@gmail.com. Tel: +9705162962.

Accepted 12 June, 2012

An investigation on the "Response of sweet corn hybrid to varying plant densities and nitrogen levels" was conducted during kharif season, 2009 at Agricultural Research Institute, Hyderabad. The experiment was conducted on a clay loam soil of medium fertility with twelve treatment combinations including three levels of plant densities 66,666 (P1), 80,000 (P2), 100,000 (P3) plants ha^{-1} and four nitrogen levels 120 (N1), 160 (N2), 200 (N3), 240 (N4) kg ha^{-1} in a randomized block design (RCBD) with factorial concept in three replications. Plant density of 80,000 ha^{-1} gave a maximum green cob yield of 14,159 kg ha^{-1} while 100,000 ha^{-1} produced highest green fodder yield of 18,532 kg ha^{-1}. Nitrogen uptake at harvest was maximum with 80,000 plants ha^{-1}. Growth characters like plant height, leaf area index (LAI) and dry matter accumulation increased due to increased level of nitrogen application from 120 to 240 kg ha^{-1}. All the yield attributes such as cob length, cob girth, fresh cob weight, number of kernels per cob and 100 kernel weight were maximized at 240 kg N ha^{-1} level. The treatment combination of P2N4 (80,000 plants ha^{-1} with application of 240 kg N ha^{-1}) gave maximum cob yield (18,090 kg ha-1), net returns and B:C ratio (4.25) followed by P2N3. The results suggest for adoption of sweet corn hybrid with plant density of 80, 000 ha^{-1} along with the application of 240 kg N ha^{-1} in clay loam soils with low available status of nitrogen during 'kharif' season for obtaining higher yield, net returns and B:C ratio.

Key words: Sweet corn, nitrogen, plant density.

INTRODUCTION

Maize (*Zea mays* L.) is a miracle crop emerging as the third most important cereal crop next to rice and wheat. It is grown for food, feed and as a source for numerous industrial products. Its array of diversity of uses and large hidden potential for exploitation led the renowned Nobel laureate, Norman E Borlaug to say that " last two decades saw the revolution in rice and wheat; the next few decades will become the maize era". India is the seventh largest producer of maize in an area of 8.11 million hectares with a production of 18.9 million tones and 2335 kg ha^{-1} productivity. Whereas, in Andhra Pradesh, it is cultivated in an area of 0.85 million hectares s with a production of 4.22 million tones and 4965 kg ha^{-1} productivity (CMIE, 2010).

Sweet corn is one type of maize and contains 13 to 15% sugar in immature grains. Sweet corn is consumed at the soft dough stage with succulent grains, emerges as an alternative dish of urbanites namely, vegetable, roasted ears, soups, corn syrup and sweeteners etc. It also found a special niche in the preparation of native beer. Sweet corn can be harvested within 80 to 90 days after sowing. They are harvested earlier by 35 to 45 days compared to normal grain corn. Presently, greater emphasis is given to the cultivation of sweet corn due to increasing demand. There is an increasing tendency to produce sweet corn at commercial level to augment the income of the farming community dwelling in the outskirts of big cities and metropolis. Since there is limited scope to increase the area under sweet corn cultivation because of competition from other cereals and cash crops, the only alternative is through enhancement of productivity by various management factors.

It is an established fact that higher grain yield depends on optimum plant density and adequate fertilizer application in particular, nitrogen. It is the proper plant density which is important from the point of intercepting sunlight for photosynthesis besides, efficient use of plant nutrients and soil moisture. Correlating these functions to produce the highest possible yields with the greatest efficiency has been the aim of this research. Therefore, matching optimum plant density with fertilizer schedule is essential to achieving the targeted yields.

However, no systematic research has been conducted to develop site and situation specific production technology for this crop, there is need to establish a relationship between plant densities and nitrogen. The information on response of highly productive maize hybrids to higher levels of nitrogen beyond the present level of recommendation is meager. Therefore, the present study entitled "Response of sweet corn hybrid to varying plant densities and nitrogen levels" was undertaken with the following objectives:

1. To study the effect of plant densities and nitrogen levels on growth, yield and quality of sweet corn hybrid.
2. To optimize plant density under variable nitrogen levels.
3. To work out economics and benefit-cost ratio under different plant densities and nitrogen levels.

MATERIALS AND METHODS

Location of the experimental site

The present investigation was carried out at the Agricultural Research Institute, Rajendranagar, Hyderabad during *kharif* 2009. The farm is geographically situated at an altitude of 542.3 m above mean sea level at 17^0 19' N latitude and 78°28' E longitude and falls under the Southern Telangana agro climatic zone of Andhra Pradesh.

Weather during crop growth period

The weekly mean meteorological data recorded during the crop growth period (23rd July to 7th October, 2009) at meteorological observatory, Agricultural Research Institute, Rajendranagar, Hyderabad. The weekly mean maximum temperature during the crop growth period ranged from 28.4 to 33.9°C with an average of 31.2°C while the weekly mean minimum temperature ranged from 21.5 to 24.2°C with an average of 22.7°C. Relative humidity I and II fluctuated between 71 to 93% and 41.9 to 88.9% respectively. Total rainfall received was 457.1 mm in 25.0 rainy days. The weekly mean sunshine hours varied from 1.9 to 7.4 with an average of 5.2 h per day and mean evaporation ranged from 6.8 to 7.8 mm with an average of 7.3 mm per day. The mean wind speed ranged from 2.2 to 16.2 km h^{-1} with an average of 6.8 km h^{-1}. At all stages of the crop growth, the weather was congenial for growth and development of maize crop.

Experimental details

Design and layout

The experiment was laid out in randomized complete block design (RCBD) with factorial concept and replicated thrice with twelve treatments.

Treatments

The details of the treatments are as follows: Plant densities: P_1 – 66,666 plants ha^{-1} (60 × 25 cm); P_2 – 80,000 plants ha^{-1} (50 × 25 cm) and P_3 – 100,000 plants ha^{-1} (40 × 25 cm): Nitrogen levels: N_1 - 120 kg N ha^{-1}; N_2 - 160 kg N ha^{-1}; N_3 - 200 kg N ha^{-1} and N_4 - 240 kg N ha^{-1}.

Plot size

Details of the plot size are as follows: Gross plot - 6.0 m × 4.0 m = 24 m^2 and Net plot - P_1 - 4.2 m × 3.25 m = 13.63m^2; P_2 - 4.5 m × 3.25 m = 14.63 m^2; P_3 - 4.8m × 3.25 m = 15.6 m^2.

Variety

Sweet corn hybrid, Sugar-75 was used in the present study. It matures in 80 to 85 days and suitable for both *kharif* and *rabi* cultivation in Andhra Pradesh, India.

Details of cultural operations

Preparatory tillage

The experimental field was prepared thoroughly by working with tractor mounted disc plough followed by tractor drawn cultivator twice and finally harrowed to achieve optimum tilth, subsequently leveling was done and plots were laid out as per the plan.

Seeds and sowing

As per the recommendation to get desired plant population, the seeds were dibbled at a depth of 2 to 3 cm in conventionally tilled soil followed by a light irrigation to ensure proper and uniform germination.

Thinning

Thinning was done at 10 days after sowing (DAS) by leaving one healthy seedling per hill.

Fertilizer application

The nitrogen fertilizer as per treatment that is, 120, 160, 200 and 240 N kg ha^{-1} in the form of urea and 60 kg ha^{-1} Phosphorus in the form of Diammonium phosphate (DAP) and 50 kg ha^{-1} of potash in the form of muriate of potash were applied. Entire phosphorus and potash were applied as basal. Nitrogen fertilizer was applied in three split doses as per schedule that is, $1/3^{rd}$ N as basal $1/3^{rd}$ N at 30 DAS and remaining $1/3^{rd}$ N at 55 to 60 DAS.

Weeding

Atrazine at the rate 1.5 kg active ingredient (a. i.) ha^{-1} was applied as pre-emergence spray after sowing and irrigation. Hand weeding was done whenever necessary.

Irrigation

All the plots were uniformly irrigated as and when required based on soil moisture content and phenological stages of the crop growth.

Plant protection

Endosulfan at 2 ml L^{-1} of water was sprayed twice to control stem borer at the initial stage.

Harvesting

Cobs were harvested by observing maturity signs like green cobs of full size with tight husk, dry brown silks, smooth and plumpy kernels which exude milky liquid when punctured with thumb nail. The cobs of border rows of each plot were harvested and separated first and later the cobs from the net plot were harvested. Green fodder was immediately harvested and weight was recorded in the net plots.

Experimental observations on crop

Five plants were tagged at random in the net plot in each treatment to record periodical observations on growth characters, yield attributes and yield of the crop.

Growth characters

Plant height (cm): Plant height was recorded at 15, 30, 45, 60 DAS and at harvest from the base of the plant to the ligule of the last leaf before tasseling and up to the tip of the tassel after tassel emergence. The observations were made on the tagged plants and expressed in cm.

Leaf area index (LAI): Five plants were collected in each treatment outside the net plot area leaving border rows and leaf area was measured using LI 3100 leaf area meter (LI-COR, Lincoln, Nebraska, USA) at 15, 30, 45, 60 DAS and at harvest and the Leaf area index (LAI) was calculated by using the formula:

$$LAI = \frac{\text{Total leaf area}}{\text{Unit ground area}}$$

Dry matter production (kg ha^{-1}): Five plants were uprooted from the destructive sampling area at 15, 30, 45, 60 DAS and at harvest and were sun-dried initially and subsequently dried in hot air oven at 60°C till constant weight was obtained. These weights were recorded and expressed in kg ha^{-1}.

Crop growth rate (CGR): Three plants were uprooted from the destructive sampling area at 15, 30, 45, 60 DAS and at harvest and were sun-dried initially and subsequently dried in hot air oven at 60°C till constant weight was obtained and CGR was calculated by using the formula:

$$CGR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{\text{Ground area}}$$

Days to 50 % flowering: The number of days taken by 50% of the plants from date of emergence to the flowering in net plot in each treatment was considered as days to 50% flowering.

Yield attributes

Number of cobs per plant: Total number of cobs from the tagged five plants were counted at harvest and expressed as average number of cobs per plant.

Cob length: The cob length from selected five plants was measured from the base to tip of the cob and the mean was computed as cob length in centimeters.

Cob girth: The cob girth from selected five plants was measured at the centre of the cob and the mean was expressed as cob girth in centimeters.

Number of kernel rows per cob: Total number of kernel rows per cob from the five fresh cobs (dehusked) was counted, averaged and expressed as number of kernel rows per cob.

Number of kernels per row: Number of kernels per row from the five cobs was counted, averaged and expressed as number of kernels per row.

100 kernel weight (g): 100 Kernels from five fresh cobs immediately after harvest, weighed and average weight was expressed in grams.

Green cob Weight with husk (g): The green cobs with husk from five labelled plants were weighed and average weight was expressed in grams per plant.

Green cob Weight without husk (g): The green cobs without husk from five labelled plants were weighed and average weight was expressed in grams per plant.

Yield

Green cob yield with husk

Green cobs (with husk) harvested from the net plots were weighed and expressed in kg ha^{-1}.

Green fodder yield (kg ha^{-1})

After picking of green cobs, the left over plants were immediately cut to the base and the green fodder from net plot was weighed and expressed in kg ha^{-1}.

Table 1. Quality analysis of kernel

Quality parameter	Standard method
Kernel crude protein content (%)	% N × 6.25
Sugar content (sucrose %)	Hand refractometer (RB - 3.06)/ 0.97 (refractometer brix reading)

$$\text{Nitrogen response} = \frac{\text{Cob yield}}{\text{Amount of nitrogen applied}} \text{ kg ha}^{-1}$$

Quality analysis of kernel

The important parameters of kernel were analyzed in the laboratory following standard procedures as indicated (Table 1).

Economics

The cost of cultivation for each treatment was computed. Similarly gross returns were calculated based on current market price of the produce. The net returns were obtained after deducting the cost of cultivation from gross returns. Benefit-cost ratio was computed using the following formula:

$$\text{B: C ratio} = \frac{\text{Net returns}}{\text{Cost of cultivation}}$$

Statistical analysis

The data on the observations made were analyzed statistically by applying the technique of analysis of variance for randomized complete block design with factorial concept and significance was tested by F-test. Critical difference for examining treatment means for their significance was calculated at 5% level of probability. Standard error of mean and critical difference on interaction is presented only where ever there is significant difference among the treatments.

Chemical analysis

Soil analysis

Soil samples were drawn from 0 to 15 cm depth in treatment plots before and after harvest of the sweet corn crop and analyzed for available nitrogen (alkaline permanganate method), available phosphorus (Olsen's method), and available potassium (N N NH_4, OAC, Jackson, 1973).

Plant analysis

Plant samples were drawn from the border rows of the treatment plots and analyzed using the following methods: Nitrogen content in sweet corn plant at 15, 30, 45, 60 DAS and at harvest was estimated. Phosphorus and potassium content were determined in the extracts after digesting the plant material with tri acid mixture of 9: 4: 1 (HNO_3: H_2SO_4: $HCLO_4$). The nitrogen, phosphorus and potassium content were expressed as percentage. The uptake of N, P and K by sweet corn crop was computed on the basis of dry matter accumulation and expressed as kg ha^{-1}.

RESULTS AND DISCUSSION

Growth characters

It was found that among different plant densities (Table 2), higher density of 100,000 ha^{-1} registered maximum plant height (219.3 cm), and found significantly more than those recorded by 66,666 and 80,000 ha^{-1}. Increased plant height at high plant density (100,000 ha^{-1}) have not contributed to increased dry matter, however, it has resulted in more LAI.

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 high population densities, the plant tends to grow taller. Such increase in height of the plant at high population densities was reported by Ashok (2009). The increase in LAI with increase in plant density was due to more number of plants per unit area.

The research findings of Suryavanshi et al. (2008) also indicated the fact that high plant density recorded more LAI as compared to low plant density. Dry matter production (kg ha^{-1}) increased with increase in plant density from 66,666 to 100,000 in early stage of the crop that is, 15 and at 30 DAS and later dry matter production (kg ha^{-1}) decreased with increasing plant density from 80,000 to 100,000 ha^{-1}. Greater reduction in dry matter production was observed with increase in plant density from 80,000 to 100,000 ha^{-1}.

It was evident from the results that increased dry matter production at the density of 80,000 ha^{-1} might be due to less inter plant competition for space, light, nutrients and moisture and better utilization of available resources. Each individual plant had adequate quantities of plant nutrients from relatively larger volume of soil up to reaching an optimum plant density of 80,000 from 66,666 ha^{-1} but further increase in plant density to 100,000 plants ha^{-1} enforced the heavy competition for resources resulting in decreased dry matter production.

Crop growth rate (g/unit area /time) showed increasing trend with increasing age of crop from 15 to 45 DAS and followed decreasing trend. This indicates that crop growth was faster during early crop growth stage. CGR increased with increasing plant density from 66,666 to 80,000 ha^{-1} and was then followed by a decreasing trend at the remaining stages. The same pattern of CGR was also observed at higher density (100,000 plants ha^{-1}) but

Table 2. Growth and yield attributing characters as influenced by varying plant densities and nitrogen levels.

Treatment	Plant height (cm)	Leaf area index	Dry matter production (kg ha^{-1})	Crop growth rate (g/unit area/time)	Days to 50% flowering	Cob length (cm)	Cob girth (cm)	Cob weight with husk (g per cob)	Cob weight without husk (g /cob)
Plant densities ('000 ha^{-1})									
66.6	186.8	3.08	8448.2	0.82	45	18.6	14.6	275.3	208.3
80.0	206.6	4.06	10175.3	0.60	46	18.0	14.3	268.8	187.4
100.0	219.3	5.10	9123.3	0.48	46	16.3	13.6	223.9	164.0
SEM ±	0.44	0.02	47.59	0.05	0.03	0.26	0.12	2.44	2.52
CD (p = 0.05)	1.29	0.06	139.61	0.14	0.09	0.75	0.34	7.16	7.38
Nitrogen levels (kg ha^{-1})									
120	198.8	3.11	8022.7	0.55	46	16.2	13.3	225.0	169.9
160	202.6	4.08	8570.3	0.46	46	17.1	14.1	258.2	181.4
200	205.4	4.36	9683.5	0.74	46	18.0	14.5	267.1	194.1
240	210.2	4.76	10719.3	0.80	45	18.9	14.8	275.2	200.8
SEM ±	0.50	0.02	55.95	0.05	0.03	0.29	0.13	2.82	2.90
CD(0.05)	1.49	0.07	161.21	0.16	0.10	0.86	0.40	8.27	8.52
P x N Interaction									
SEM ±	0.88	0.04	95.18	0.09	0.06	0.51	0.23	4.88	5.03
CD (p = 0.05)	2.58	0.12	279.22	0.27	0.18	NS	NS	NS	NS

the crop growth rate was found much less at all the stages compared to the rest of the two plant densities. This reduced growth rate could be attributed to onset of intra and inter plant competition.

Translocation of food materials from source (leaf) to sink (reproductive parts) was more at low plant density. Plants in lower density level attained early flowering stage because of early vigorous growth due to less competition among the plants, it hastened maturity. Similar results that is, delay in flowering and maturity period due to dense planting was observed by Muniswamy et al. (2007).

All the growth parameters significantly and positively responded to increasing levels of nitrogen application. At harvest, the plant height, LAI dry matter and CGR were significantly more with 240 kg N ha^{-1} compared to its lower doses of nitrogen. As maize hybrids are highly responsive to applied inputs in particular, nitrogen at higher doses supported the crop requirement. Nitrogen at the rate of 240 kg ha^{-1} promoted better growth and resulted in higher uptake of nitrogen, phosphorus and potassium as compared to lower levels. These nutrients triggered the vigorous growth of plants, thereby achieving more LAI; this further boosted the dry matter production and hastened the flowering and maturity period. Similar response of growth parameters to applied nitrogen levels was reported by Muniswamy et al. (2007).

Interaction effect of plant densities and nitrogen levels on LAI revealed that higher plant density at higher levels of nitrogen produced the highest LAI. Leaf area index increased at a given plant density with increase in fertility level. Similarly at a given fertility level, the LAI increased with increase in plant density but the magnitude of increase in LAI due to plant density was more at high fertilitylevel. Supply of adequate nutrition and moisture regime and light etc enhanced LAI (Muniswamy et al., 2007). Though the highest dose of nitrogen (240 kg ha^{-1}) at highest plant density (100,000 ha^{-1}) responded to greater improvement in growth characters, interaction effect disproved this and proved that the same nitrogen dose has produced more dry matter and CGR even at density of 80,000 ha^{-1}, indicating the manifestations occurring in plant community due to several uncontrolled factors involved.

Yield attributes

Number of green cobs per plant did not show any significant variation due to different plant densities. But cob length, cob girth, cob weight with husk, number of kernels per row and number of kernels per cob were highly influenced by varying plant densities. Higher values for the aforementioned characters were observed at low plant density (66, 666 ha^{-1}) and it was at par with 80,000 ha^{-1} and lower values were associated with higher plant density (100,000 ha^{-1}).

This clearly indicated that plants at lower density fully exploited the natural resources efficiently, besides responding to externally applied inputs and expressed the same liberally compared to plants at highest plant density where the competition was stiff. The findings of Ashok (2009) confirmed these results. The plant density at 66,666 ha^{-1} recorded higher values and even differed significantly from 80,000 ha^{-1} for yield attributes namely, cob weight without husk, number of kernel rows per cob and 100 kernel weights, indicating a stress free environment.

However, highest plant density (100,000 ha^{-1}) recorded more number of cobs ha^{-1} though it recorded significantly lower values for all the above discussed yield attributes. Surprisingly, the cob yield obtained with plant density of 80, 000 ha^{-1} produced more cob yield compared to 100,000 and 66,666 ha^{-1}. Each increment of nitrogen from 120 to 240 kg ha^{-1} influenced the yield attributes markedly. Nitrogen at 240 kg ha^{-1} significantly improved all the yield attributes.

Application of 240 kg N ha^{-1} recorded significantly more cob length and girth, number of cobs ha^{-1}, weight of green cobs and number of kernels per cob over its immediate lower dose which recorded similar values for yield attributes (cob length and girth, cob weight with and without husk) compared to 200 kg N ha^{-1} and both of these differed significantly from 120 and 160 kg N ha^{-1}, but highest dose (240 kg N ha^{-1}) differed significantly even from 200 kg N ha^{-1} for yield attributes (Number of kernel rows per cob, 100 kernel weight, number of kernels per row, number of kernels per cob and number of cobs ha^{-1}).

This evidently proved that increased availability of nitrogen to crop at higher levels resulted in production of longer cobs accompanied by increased grain filling that gave more kernels per cob. Not only grain filling but also size of grain was also better as supported from increase in 100 grain weight. Better corn and grain development was due to increased availability of nitrogen and greater production of photosynthates and their efficient translocation for development of reproductive parts. Similar results were reported by Sahoo and Mahapatra (2004) and Kar et al. (2006).

Yield

The varying plant densities and nitrogen levels significantly affected the green cob and fodder yields (Table 3). There was significant improvement to an extent of 35.8% in cob yield due to increasing plant density from 66,666 to 80, 000 ha^{-1}. Lower yields at 66,666 plants ha^{-1} were due to production of number of cobs. When planting density was further increased from 80,000 to 100, 000 ha^{-1} the cob yield reduced considerably to the tune of 53.1% as compared to 80, 000 ha^{-1}. At higher plant density of 100, 000 ha^{-1} more competition for resources occurred and reduced the values of different yield attributes. The individual plants growth at higher plant density was affected more due to mutual shading and greater interplant competition. The internal competition within the individual plant between vegetative and reproductive parts became more as competition between plants increased with higher plant densities. The findings of Sahoo and Maha (2007) confirmed these results. Plant density per unit area significantly influenced the green fodder yield. Increase in plant density significantly increased green fodder yield being maximum at 100, 000 ha^{-1}. Linear increase in green fodder yield with increasing plant density was also noticed by Ashok (2009).

The protein content of kernel was influenced by plant densities. There was reduction in protein content of grain with increased plant density which might be due to inadequate availability of nitrogen as a result of competition. Similar observations were made by Singh et al. (1997).

The cob and fodder yields and protein content were significantly affected by nitrogen levels. Each successive increase in nitrogen levels enhanced the green cob yield to the tune of 36, 13.2 and 12.3%.with the application of 160, 200 and 240 kg N ha^{-1} respectively over 120 kg N ha^{-1}. Ameta and Dhakar (2000) also reported similar findings.

Increased plant height and dry matter production with each successive increase in nitrogen levels enhanced the green fodder yield to an extent of 15, 20.9 and 30.7% with application of 160, 200 and 240 kg N ha^{-1} over 120 kg N ha^{-1} respectively.

Application of 240 kg N ha^{-1} not only enhanced the cob yield but also improved the quality of grain as evidenced in higher protein content. The increased supply of nitrogen increased the protein content of grain since nitrogen is the constituent of protein molecule. Similar increase in protein content with increase in nitrogen level was observed by Krishna et al. (1998) and Raja (2001).

Study of interaction effects of plant densities and nitrogen levels revealed that green cob yield increased due to increase in nitrogen level at same level of plant

Table 3. Yield attributes, yield and quality parameters as influenced by varying plant densities and nitrogen levels.

Treatment	Number of kernel rows cob^{-1}	100 Seed weight (g)	Number of kernels row^{-1}	Number of kernels cob^{-1}	Number of cobs ha^{-1}	Green cob yield (kg ha^{-1})	Green fodder yield (kg ha^{-1})	Sucrose content (%)	Crude protein content (%)
Plant densities ('000 ha^{-1})									
66.6	16.4	28.9	33.3	452.8	62006.7	10225.6	15040.2	14.8	10.1
80.0	14.1	27.8	33.1	441.2	75667.2	14159.0	16584.8	14.4	9.2
100.0	12.3	25.5	28.5	341.4	89987.8	9247.9	18532.8	14.1	8.7
SEM ±	0.41	0.40	0.24	4.22	362.39	178.29	153.68	0.16	0.12
CD (p = 0.05)	1.19	1.17	0.70	12.37	1063.14	523.04	450.83	0.48	0.36
Nitrogen levels (kg ha^{-1})									
120	13.1	23.1	27.3	317.2	69384.6	8494.1	14315.3	13.5	8.0
160	14.0	26.0	31.5	404.8	73449.4	10554.8	16525.8	14.2	9.0
200	14.7	28.9	32.8	450.3	78551.9	12088.8	17316.0	14.8	9.7
240	15.2	31.7	34.8	474.9	82163.0	13705.8	18719.8	15.4	10.5
SEM ±	0.47	0.46	0.27	4.87	418.46	205.87	177.45	0.19	0.14
CD (0.05)	1.38	1.35	0.81	14.28	1227.61	603.96	520.58	0.55	0.41
P x N Interaction									
SEM ±	0.81	0.79	0.48	8.43	724.79	356.58	307.35	0.33	0.24
CD (p = 0.05)	NS	NS	1.40	24.73	2126.28	1046.09	901.67	NS	NS

density. Highest green cob yield was obtained at 80, 000 plants ha^{-1} and 240 kg N ha^{-1}. This plant density of 80,000 ha^{-1} might be an optimum density at which interplant competition was sufficiently severe at the time of floral initiation to reduce the growth primordial to a level at which the load on individual plant was not excessive, resulting in maximum green cob production. As the experimental soil is deficient in available nitrogen, it responded well to increased levels of nitrogen up to 240 kg ha^{-1}. The enhanced uptake of nitrogen resulted in more dry matter production at the same plant density that supported yield attributing characters exclusively number of kernel rows and number of kernels per cob that reflected in more cob yield. Similar response of normal corn yield and sweet corn cob yield to nitrogen levels and population interaction was reported by Misra et al. (1994) and Tyagi et al. (1998).

Economics

The maximum net returns and net returns (Table 5), per rupee invested (B:C ratio) were found with plant density of 80,000 ha^{-1} both lower and higher levels over 80,000 ha^{-1} reduced the net returns and benefit cost ratio. Sahoo and Maha (2007) and Ashok (2009) also reported higher net returns at 83,333 plants ha^{-1}. There was a marked improvement in net returns and benefit cost ratio with each successive increase in nitrogen level from 120 to 240 kg ha^{-1}. The maximum net returns were noticed with 240 kg N ha^{-1}. The benefit cost ratio was also enhanced with higher nitrogen levels. Higher yields of green cobs and fodder directly contributed to the returns at higher nitrogen levels. Ashok (2009) observed similar results. The treatment combination of 80,000 plants ha^{-1} with application of 240 kg N ha^{-1} due to interaction gave maximum net returns and B:C ratio (4.25).

Nutrient uptake

Nutrient uptake is the function of nutrient concentration in plant parts and dry matter yield of

Table 4. Nutrient balance sheet.

Treatment	Nitrogen uptake (kg ha^{-1})	Phosphorus uptake (kg ha^{-1})	Potassium uptake (kg ha^{-1})	Nitrogen	Phosphorus	Potassium
Plant densities ('000 ha^{-1})						
66.6	112.0	26.2	83.1	222.0	19.5	104.4
80.0	140.7	30.7	101.8	217.6	18.5	95.5
100.0	136.7	19.7	77.2	230.5	20.8	109.2
SEM ±	2.87	0.76	1.31	1.40	0.23	0.54
CD(p = 0.05)	8.41	2.22	3.86	4.12	0.68	1.59
Nitrogen levels (kg ha^{-1})						
120	89.2	25.5	87.4	209.7	16.9	97.3
160	121.4	31.1	96.7	217.5	19.3	102.3
200	147.1	35.9	108.2	225.7	20.4	104.8
240	161.5	38.8	116.3	240.5	21.8	107.6
SEM ±	3.31	0.87	1.52	1.62	0.26	0.62
CD(0.05)	9.71	2.57	4.45	4.76	0.79	1.84
P x N Interaction						
SEM ±	5.74	1.52	2.63	2.81	0.46	1.08
CD (p = 0.05)	16.82	4.45	7.71	NS	NS	NS

Table 5. Economics cost benefit analysis.

Treatment combinations	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
P_1N_1	17986	47364	29378	1.63
P_1N_2	18420	64632	46212	2.51
P_1N_3	18855	73870	55015	2.92
P_1N_4	19290	85678	66388	3.44
P_2N_1	19486	66257	46771	2.40
P_2N_2	19920	87883	67963	3.41
P_2N_3	20355	97858	77503	3.81
P_2N_4	20790	109169	88379	4.25
P_3N_1	20986	48004	27018	1.29
P_3N_2	21420	62927	41507	1.94
P_3N_3	21855	70208	48353	2.21
P_3N_4	22290	75879	53589	2.40

B:C, benefit cost ratio.

the crop. Higher green cob and fodder yield at 80,000 plants ha^{-1} resulted in the highest nutrient uptake, (Table 4). While the nutrient uptake both at 66,666 and 100,000 plants ha^{-1} levels remained significantly lower than 80,000 plantsha^{-1}. Nitrogen application also enhanced the nitrogen uptake with its each increment up to 240 kg ha^{-1}. The externally applied nitrogen supported native available nitrogen that resulted in higher nitrogen concentration that was sufficient to meet the requirement at higher yield of sweet corn. A similar observation was made by Kar et al. (2006) and Ashok (2009).

ACKNOWLEDGEMENTS

The author wish to express his appreciation to N. G. Ranga Agricultural University and Government of Andhra Pradesh for their financial support offered during the course of the investigation

REFERENCES

Ameta GS, Dhakar LL (2000). Response of winter maize (*Zea mays*.L) to nitrogen levels in relation to varying population density and row

spacing. International journal of tropical Agriculture 18(4): 395-398.
Ashok KR (2009). Production potential and nitrogen use efficiency of sweet corn (Zea mays) as influenced by different planting densities and nitrogen levels. Indian J. Agric. Sci., 79(5): 351-355.
CMIE (2010).Centre of Monitoring India Economy Pvt.Limited,Apple Apetile,Mumbai.
Kar PP, Barik KC, Mahapatra PK, Garnayak LM, Rath BS, Bastia DK, Khanda CM (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.
Krishna A, Raj Khelka SV, Sambasiva RA (1998). Effect of planting pattern and nitrogen on fodder maize (*Zea mays*) inter cropped with cowpea (*Vigna unguiculata*). Indian J. Agron., 43(2): 237-240.
Misra BN, Yadav RS, Rajput AI, Pandey SM (1994). Effect of plant geometry and nitrogen application on yield and quality of winter maize. Indian J. Agron., 39: 468-469.
Muniswamy S, Rame G, Rajendra PS (2007). Effect of spacing and nitrogen levels on seed yield and quality of maize single cross hybrid PEHM-2. Mysore J. Agric. Sci., 41 (2) : 186-190.
Raja V (2001). Effect of nitrogen and plant population on yield and quality of super sweet corn (*Zea mays*). Indian J. Agron., 46(2): 246-249.
Sahoo SC, Mahapatra PK (2004). Response of sweet corn (*Zea mays*) to nitrogen levels and plant population. Indian J. Agric. Sci., 74 (6):337-338.
Sahoo and Mahapatra (2007). Yield and economics of sweet corn (Zea mays) as affected by plant population and fertility levels. Indian Journal of Agronomy 52(3) : 239-242.
Singh AK, Singh GR, Dixi TRS (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.
Suryavanshi VP, Chavan BN, Jadhav KT, Pagar PA (2008). Effect of spacing, nitrogen and phosphorus levels on growth, yield and economics of *kharif* maize. Int. J. Tropical Agric., 26 (3-4):287-291.
Tyagi RC, Devender S, Hooda IS (1998). Effect of plant population, irrigation and nitrogen on yield and its attributes of spring maize (*Zea mays*). Indian J. Agron., 43(4):672-676.