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Efficient Need Based Nitrogen Management in *Rabi* Maize (*Zea mays* L.) using Leaf Colour Chart Under Varied Planting Density

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ABSTRACT

The field experiments were conducted for two consecutive *rabi* seasons (November –March) of 2017–18 and 2018–19 at the Wet land farm of S.V. Agricultural College, Tirupati to calibrate leaf colour chart (LCC) for increasing growth yield, nitrogen uptake under varied plant density to establish and evaluate threshold leaf colour greenness as a guide for in-season need based fertilizer N in maize. Research results indicated that the planting density, nitrogen levels and LCC threshold values significantly influenced all the growth and yield attributes, yield and nitrogen uptake. Plant height, days required to 50% tasselling and silking, cob yield, harvest index and nitrogen uptake increased significantly with increase in plant density i.e., 1,11,111 plants ha^{-1} with application of fertilizer nitrogen at higher dose i.e. 40 kg ha^{-1} and by using higher LCC threshold value (LCC 5) in different splits. Whereas, leaf area planr^{-1}, cob girth, number of kernels rows cob^{-1} and number of kernels cob^{-1} was lessened significantly with increase in planting density, however it was increased with application of nitrogen at higher rate i.e., 40 kg ha^{-1} by using higher LCC threshold value (LCC 5) at various splits. Eventually, experimental results manifested that, fine-tuning of N dose and time of application by number of splits which synchronize the crop demand was the best management strategy for sustainable crop growth, production and productivity of maize.

KEYWORDS: LCC, maize, nitrogen, nitrogen uptake, planting density

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1. INTRODUCTION

Globally, among the cereal crops, maize is third next to wheat and rice in terms of utility and consumption (Singh and Longkumer 2021; Pallavi et al., 2021). In India, the production maize has augmented almost sixteen folds, from 1.73 to 27.80 mt from 1950–51 to 2018–19. The increase in yield might be due to improved agronomic practices such as, increase in plant density, fertilizer application rate and planting time (Srivastava et al., 2018). The maize area has reached to 9.2 mha in India during 2018–19 (Anonymous, 2020). However, the 2.9 t ha^{-1} productivity of India is far behind the global average of 5.6 t ha^{-1}. This gap is largely attributed to shorter duration of the crop in India and weather volatilities of the rainfed environment, where four-fifths of maize production area lies (Annual Report, 2020).

Fertilizer nitrogen (N) considered as a most crucial nutrient, being the most yield-limiting factor in crops, its stress minimizes growth and yield particularly in maize. Poor nitrogen utilization in maize crop is mainly owing to inclusion of excessive nitrogenous fertilizers by farmers without assessing the crop-N demand and crop growth stage. Nitrogen is lost from the soil-plant system, leading to low N use efficiency when N application is not synchronized with crop demand (Singh et al., 2002 and Rochette et al., 2013). Improper fertilization practices have been known to cause nitrate leaching into aquatic systems (Fang et al., 2013) and ecological impacts for downstream from their source. Therefore, the best remedy could be to synchronize N application with the crop demand. It can be achieved by following need-based N management on periodic assessment of plant N status using different gadgets for efficient nitrogen use and delayed application of fertilizer N until the N level goes below a critical level. Few gadgets like chlorophyll meter and inexpensive leaf colour chart (LCC) Ghosh et al., 2013 are simple and quick for measuring relative content of chlorophyll in leaf which is directly proportional to leaf N content without destructing plants.

Plant population is one of the major limiting factors for maize production in India. Because it affects plant architecture, alters growth and developmental pattern, effect on carbohydrate production and partition. Optimized plant architecture renders modern maize hybrids more productive, owing to their tolerance of high planting density (Huang et al., 2017and Ladha et al., 2000). Parallel to the increasing planting density the individual plants productivity decreases but the yield per unit area increases (Muranyi, 2015 and Argenta, G and Sangoi, 2004). It is an established fact that higher grain yield depends on optimum planting density and adequate fertilizer application particularly nitrogen. Proper planting density is important from the point of intercepting sunlight for photosynthesis besides, efficient use of plant nutrients and soil moisture. Maize yield differs significantly under varied planting density due to difference in genetic potential (Liu et al., 2004 and Peng et al., 1996).

Improving fertilizer nitrogen use efficiency (NUE) in maize is vital not only to improve and sustain high crop yields but also to curtail post field N application losses. As N requirement of maize plant is not same throughout the crop growth period and it is necessary to adjust fertilizer N application with the timings of plant N requirement to enhance N use efficiency in maize. Whereas, need based N management approach using LCC usage in maize crop has not been studied deeply.

Hence our hypothesis of present investigation planting density and LCC strongly influence the crop nitrogen uptake and yield of maize therefore our objective was set upto calibrate the LCC threshold for augmenting grain yield and nitrogen use efficiency in *rabi* maize under varied planting density.

2. MATERIALS AND METHODS

2.1. *Characterization of experimental site and treatment details*

A field investigation was carried out for two consecutive *rabi* seasons of 2017–18 and 2018–19 at the Wet land farm of Sri Venkateswara Agricultural College, Tirupati, Andhra Pradesh, India. The farm is situated at 13.6°N latitude, and 79.3°E longitude with an average altitude of 182.9 m above mean sea level, in the Southern Agro-climatic Zone of Andhra Pradesh. During the cropping period of maize, average temperature ranged from 13.3^{0}C to 38.5^{0}C in 2017 and 16.2^{0}C to 38.4^{0}C in 2018. Average rain fall was (43.3 mm in 2017 and 128.2 mm in 2018) during both the years. The experimental soil was sandy clay loam, with normal electrical conductivity (0.15 dSm^{-1}), slightly alkaline (pH 7.8) with low organic carbon (0.28%), low in available nitrogen (183 kg ha^{-1}), medium in available phosphorus (26.2 kg ha^{-1}) and medium in available potassium (187 kg ha^{-1}).

2.2. *Experimental design and treatments*

Experiment was laid out in split-split plot design with three replications. The treatments consisted of three planting densities (P_1:66,666, P_2: 83,333 and P_3:1,11,111 plants ha^{-1}) as main plots, three nitrogen levels (N_1:30, N_2:35 and N_3: 40 kg N ha^{-1}) as sub plots and three LCC threshold values (L_1: LCC 4, L_2: LCC 4.5 and L_3: LCC 5) as sub-sub-plots.

2.3. *Crop management*

Maize hybrid (DHM–117) was used as test cultivar in the field investigation using three different spacing viz., 75×20 cm^2, 60×20 cm^2 and 45×20 cm^2. However, recommended dose of 80:80 kg P_2O_5 and K_2O ha^{-1} through SSP and MOP were applied to the soil as basal along with 60 kg N ha^{-1} through urea during both the years, in all the treatments. However, remaining 180 kg urea was applied based on leaf colour chart at different splits when it falls below the LCC threshold levels at every 10 days interval from 21 days after sowing to silk emerging stage i.e., 21, 31, 41, 51 and 61 DAS. A 'six panel' LCC was used to match leaf colour in ten plants from each net plot. Observations were taken for 10 plants by placing the middle part of the youngest fully expanded and healthy leaf on the top of the colour strips in the chart. When six or more leaves read below a set critical LCC value (4, 4.5 and 5), urea was applied as per the treatments. LCC readings were taken at same time of the day (8:00–11:00 AM). Whereas, during observation LCC was not exposed directly to sunlight and leaf being measured was shielded from the sun.

2.4. Data recorded

Five randomly selected labelled plants from each net plot were taken for measuring all the data set. Height of plant measured by using metric scale and expressed in cm. Leaf area plant^{-1} was measured using LI-COR model LI-300 portable leaf area meter with transparent conveyor belt (Model I-3050 A) utilizing an electronic digital display. The number of days taken from the date of sowing to the stage when 50% plants have projected tassels out and silking in each treatment was considered as number of days to 50% tasselling and silking during both the years of experiment. Girth of five cobs was calculated by measuring the diameter with vernier calipers in the middle portion of the cobs, where the girth was found maximum and the mean cob girth was expressed in cm. Kernel rows cob^{-1} and kernels cob^{-1} from five randomly selected cobs was counted and the mean was expressed as number of kernel rows cob^{-1} and number of kernels cob^{-1}. For cob yield, harvesting cobs were removed from the plants in the net plot area, dehusked and dried on the threshing floor. The weight of cobs in each plot was recorded and expressed in kg ha^{-1}. Harvest index was calculated by the ratio of economic yield (grain yield) to the total biological yield (grain + straw yield) and expressed as% (Donald and Humblin, 1976). Available soil nitrogen at a depth of 15–30 cm after harvest of maize was analysed by Alkaline-Permanganate Method suggested by Subbiah and Asija (1956) using 0.25% $KMnO_4$ as an extractant.

2.5. Nitrogen uptake

Nitrogen content in dry matter was estimated by micro Kjeldahl method (Anonymous, 1960). The nitrogen uptake was calculated by multiplying the content of nitrogen with respective dry matter production and expressed in kg ha^{-1}.

Nutrient uptake (kg ha^{-1})=Percent of N concentration /100×Biomass yield (kg ha^{-1})

Total quantity of nitrogen saved has been calculated by measuring total nitrogen fertilizer applied in different split applications using LCC against recommended doses of nitrogen fertilizer to maize (240 kg ha^{-1}).

2.6. Statistical analysis

Fisher's method of analysis of variance was applied for the analysis and interpretation of data (Panse and Sukhatme, 1985). The significant variation among the treatment were interpreted by the critical difference (CD) at 0.05 probability level. Treatment differences which were not-significant denoted as NS. Statistical analysis of the pooled data was performed using SPSS 17.0 version package.

3. RESULTS AND DISCUSSION

3.1. Effect of planting density, nitrogen levels and LCC threshold values on growth attributes

At all the stages of crop growth, the higher density of planting viz., 1,11,111 plants ha^{-1} had produced significantly taller plants (217.7 cm) than 83,333 plants ha^{-1} (215.7 cm) and 66,666 plants ha^{-1} (211.3 cm). This might be owing to fervent competition for light at higher plant density in the plant community would compel the plants to grow taller, in search of solar light (Fromme et al., 2019). All three tested factors did not show any significant interaction with regard to plant height (Table 1).

Maximum leaf area plant^{-1} (3826.7 cm^2) was noticed with lower planting density viz., 66,666 plants ha^{-1} (Table 1) over other planting density. These results could be attributed to the intra-plant competition for the elements essential for production such as light, water and nutrients Zhai et al., 2020). Whereas, leaf area plant^{-1} increased with increase in nitrogen levels and maximum leaf area (3806.9 cm^2) was found with application of 40 kg N ha^{-1} using higher LCC threshold i.e., LCC 5 during both the years of persual. This might be owing to a greater number of green leaves plant^{-1} as well as effect of N on protein synthesis and meristematic growth through hormonal synthesis resulted in higher leaf area plant^{-1} and it influence the overall photosynthesis and yield of crop (Ullah et al., 2015). Interaction of planting density, nitrogen levels and LCC threshold values were not statistically traceable.

The number of days to reach 50% tasseling and silking was significantly earlier with lower density of planting P_1 (66,666 plant ha^{-1}) and significantly took more numbers of days at other plant density (Table 1). Vigorous growth due to lack of competition for growth resources (moisture and nutrients) and efficient utilization of nutrients might have resulted in early flowering under lower density than other plant densities. Statistical analysis of the data revealed that increasing nitrogen level along with higher LCC threshold consistently increased days to tasseling and silking. However,

Table 1: Growth and yield attributes of maize as influenced by planting density, nitrogen levels and LCC threshold values

	Plant height (cm)	Leaf area plant^{-1} (cm^2)	Days to 50% tasseling	Days to 50% silking	Cob girth (cm)	No of kernel rows cob^{-1}	Number of kernels cob^{-1}	Cob yield (t ha^{-1})	Harvest index (%)
Planting density (plants ha^{-1})									
P_1: 66,666	211.3	3826.7	58	61	16.15	14.88	425.3	8.02	35
P_2: 83,333	215.7	3651.2	59	62	16.04	15.04	406.2	8.61	36.2
P_3: 1,11,111	217.8	3601.1	59	63	15.9	14.8	369.9	9.11	36.4
SEm±	0.5	15.28	0.14	0.11	0.52	0.16	2.27	0.05	0.26
CD (p=0.05)	1.97	59.98	0.56	0.45	NS	NS	8.92	0.18	1.03
Nitrogen levels (kg ha^{-1})									
N_1: 30	211.9	3587.9	58	61	16.62	14.83	387.7	8.15	35.6
N_1: 35	214.6	3684.1	59	62	15.88	15.03	395	8.71	35.8
N_1: 40	218.3	3806.9	59	62	15.59	14.85	418.2	8.87	36.3
SEm±	0.85	24.43	0.2	0.1	0.42	0.1	2.68	0.05	0.2
CD (p=0.05)	2.63	75.27	0.63	0.3	NS	NS	8.24	0.15	NS
LCC threshold values									
L_1: LCC 4	209.5	3566.2	58	61	15.54	14.7	375.9	7.97	35.3
L_2: LCC 4.5	214.9	3707.3	59	62	16.75	15.06	406.4	8.63	35.7
L_3: LCC 5	220.4	3805.5	59	63	15.81	14.95	418.6	9.14	36.6
SEm±	1.32	24.66	0.16	0.15	0.39	0.12	2.4	0.07	0.27
CD (p=0.05)	3.77	70.71	0.47	0.44	NS	NS	6.88	0.19	0.77
Interaction									
P×N									
SEm±	1.48	42.32	0.35	0.17	0.74	0.17	4.64	0.08	0.35
CD (p=0.05)	NS	NS	NS	NS	NS	NS	14.3	0.26	NS
P×L									
SEm±	2.28	42.71	0.28	0.27	0.68	0.21	4.16	0.11	0.46
CD (p=0.05)	NS	NS	NS	NS	NS	NS	11.92	NS	NS
N×L									
SEm±	2.28	42.71	0.28	0.27	0.68	0.21	4.16	0.11	0.46
CD (p=0.05)	NS	NS	NS	NS	1.95	NS	NS	NS	NS
P×N×L									
SEm±	3.95	73.9	0.49	0.46	1.18	0.36	7.2	0.2	0.8
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

early tasseling and silking occurred with the supply of lower level of nitrogen (30 kg N ha^{-1}) with lower level of LCC threshold (LCC 4) than other rate of nitrogen and LCC threshold levels. Because lower supply of nitrogen might have triggered the lower plant growth, thereby decrease in leaf area hastened the flowering (Shrestha et al., 2018).

3.2. Effect of planting density, nitrogen levels and LCC threshold values on yield attributes

As shown in table 1, planting density, nitrogen levels and LCC threshold values did not show any significant influence on cob girth of maize. However, the average maximum cob girth of maize was observed higher in lower plant density of 66,666 plants ha^{-1} (16.15 cm) than higher plant densities viz., 1,11,111 plants ha^{-1} (15.90 cm) (Table 1). It was mainly owing to the resources like light, water and nutrients are limited at higher stand densities. Interplant competition for sunlight, nutrients and water increases with increasing crop density that why the availability of resources for individual plants will be reduced (Zeleke et al., 2018). Higher threshold of LCC 5, was found to be suitable for guiding N application to achieve higher cob girth than other LCC threshold levels (Singh et al., 2016). Interactions of nitrogen level and LCC threshold exerted significant influence on cob girth, while other interactions were non-significant (Table 1). The combination of higher nitrogen levels with higher LCC threshold (N_3L_3) recorded maximum cob girth during both the years of study and it was statistically superior than other treatment combinations (Figure 1) and it is justifying agronomic fact that higher availability and uptake of N, which is a substrate for synthesis of organic compounds, which constitute protoplasm and chlorophyll. This was the reason for the production of higher cob girth was found in treatment combination of N_3L_3.

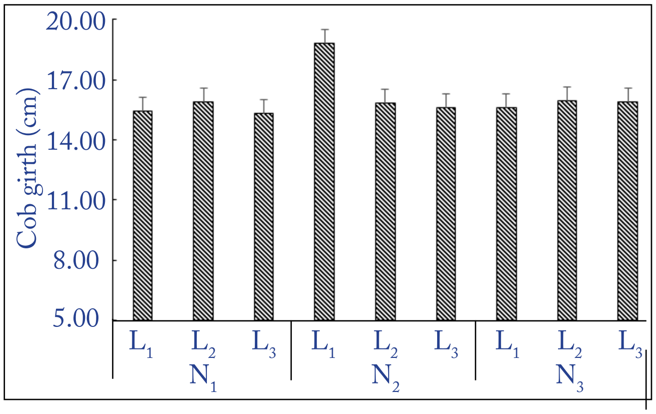

Figure 1: Interaction effect of nitrogen levels and LCC threshold on cob girth

Regards to number of kernel rows cob^{-1}, effect of planting density, nitrogen levels and LCC threshold values were not statistically significant, interactions were also not statistically traceable. Nevertheless, number of kernel rows cob^{-1} was lessened statistically with increasing stand density from 66,666 plants ha^{-1} to 1,11,111 plants ha^{-1}. Higher accumulation of dry matter in plant due to higher N applied (40 kg N ha^{-1}) based on LCC 5 which led to effective translocation of photosynthates from source to sink might have further improved the number of rows cob^{-1} (Rahman et al., 2016).

Shrink in number of kernels cob^{-1} was observed with increasing stand density from 66,666 plants ha^{-1} (425.3) to 1,11,111 plants ha^{-1} (369.9). The increase in number of kernels cob^{-1} in lower plant population might be due to availability of more resources to individual plants. When the number of individual plants per unit area is increased beyond the optimum plant density, there is a series of consequences that are detrimental to ear ontogeny that result in barrenness (Koca et al., 2017). Maximum number of kernels cob^{-1} was registered with the application of higher nitrogen levels 40 kg N ha^{-1} as compared to other N levels. It might be due to N contribution to sink size which leads to increase in the cob size and grain filling with increasing N levels. Under nitrogen stress environments there may be asynchronous flowering, abortion of seed, and ultimately reduction in the number of kernels (Rahman et al., 2016). Excessive number of kernels cob^{-1} (418.6) was obtained with LCC 5 than in LCC 4.5 (406.4) and LCC 4 (375.9). This parameter improved mainly due to increased growth performance represented by improved plant height, leaf area plant^{-1} and dry matter production. Moreover, application of N in splits according to the plant needs in the LCC practice might be the reason for better number of kernels cob^{-1} (Datturam, 2011). As shown in Figure 2 a and b, the interaction effect of planting densities and nitrogen levels as well as planting densities and LCC threshold values were significant. Among various treatment combinations higher number of kernels cob^{-1} was recorded at lower planting density of 66,666 plants ha^{-1} (P_1N_3) with application of higher N levels viz., 40 kg ha^{-1}. However, combination lower planting density with higher LCC threshold value (P_1L_3) were produce more number of kernels cob^{-1}.

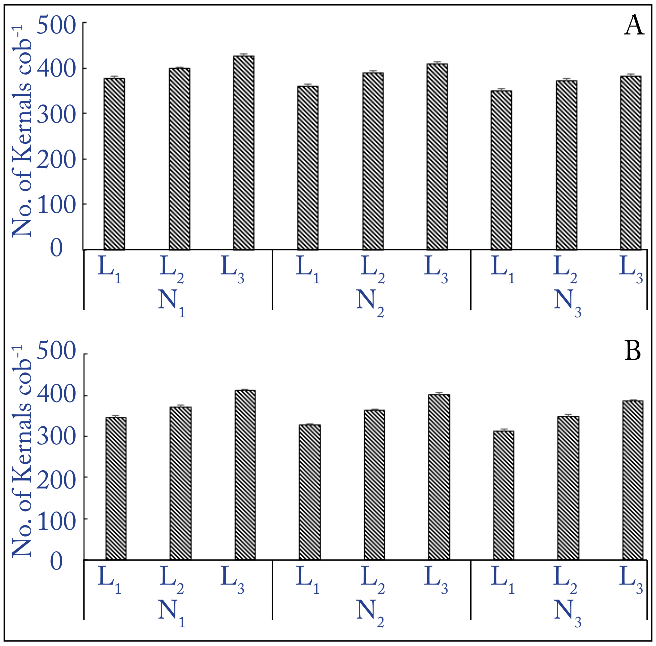

Figure 2: Interaction effect (a) planting density and nitrogen levels on number of kernels cob^{-1}; (b) planting density and leaf color chart on number of kernels cob^{-1}

Scrutiny of data pertaining to cob yield revealed that each successive increase in planting density from lower level of 66,666 plants ha^{-1} to higher level of 1,11,111 plants ha^{-1} which registered 13.6% higher production of cob yield

(Table 1). Among the different nitrogen levels, significantly maximum cob yield 8.83% was recorded a 40 kg N ha^{-1} compared to 30 kg N ha^{-1}. The improvement in cob yield with enhanced nitrogen application might be due to better availability and efficient uptake of nutrients which in turn lead to efficient metabolism and higher biomass accrual which might be responsible for production of higher cob yield (Thimmappa and Reddy, 2016). Significantly maximum cob yield was recorded 14.7% at LCC 5, than in LCC 4. The higher cob yields of maize at higher application of nitrogen at LCC 5 was mainly due to better translocation of photosynthates from source to sink (Swamy et al., 2016). Moreover, interaction effect between planting density and nitrogen levels disclosed that the combination of higher planting density along with higher nitrogen levels (P_3N_3) recorded maximum cob yield and it was statistically superior to all other treatment combinations (Figure 3). The lower kernel yield was noticed with the combination of lower planting density along with lower application of nitrogen (P_1N_1). The reason for increase in cob yield was due to the accelerated mobility of photosynthates from source to sink and its accumulation in the cobs at higher level of planting density and nutrients. Another reason for higher cob yield was the higher number of plants at higher planting density and higher uptake of nutrients at higher N levels, which was due to increased accumulation of dry matter in cobs.

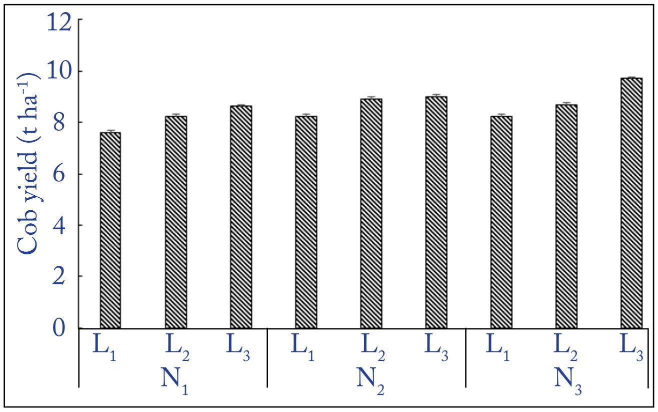

Figure 3: Interaction effect of planting density and nitrogen levels on cob yield

The perusal of the data revealed that the maximum harvest index was registered with higher planting density viz.,1,11,111 plants ha^{-1}, which was significantly higher than other planting density. The lower harvest index at lower plant densities not only due to poor yields but also due to poor vegetative growth. These results are supported by achievement of (Sharanabasappa et al., 2017). Significantly, maximum harvest index was observed with LCC 5, which was superior to LCC 4.5 and LCC 4. Nevertheless, LCC 4 recorded comparatively lower harvest index due to lower cob yields than the other LCC thresholds indicating inadequacy of nitrogen to meet the crop demand.

3.3. Effect of planting density, nitrogen levels and LCC threshold values on nitrogen uptake

Planting density, nitrogen levels and LCC threshold values had significantly affected on uptake of nitrogen (Figure 4). With regard to interaction all the tested factors were not statistically traceable during both the years of study. Uptake of nitrogen is associated with the metabolic activities of plants, the concentration of the nutrients, dry matter production and distribution of ion in the external medium. Enchantment of N uptake from lower plant density to higher density is mainly because of plants which might compete for N at a higher density with crowding stress, thus increase in production of significantly maximum straw yield at higher planting density along with increased crop growth and development under increased planting density resulted in higher dry matter accumulation, which finally reflected on nutrient uptake. Uptake of N increased significantly with each successive increment in nitrogen at all the stages of crop growth (Table 2). The maximum N uptake was noticed with application of 40 kg N ha^{-1} at different splits and lowest was found with application of 30 kg N ha^{-1}. This might be owing to better root growth and development led to increased absorption of nutrient under high nitrogen levels with various split applications and increase root cation exchange capacity, which might have enhanced the uptake of nutrients. Also this could be attributed to better synchronization of N supply with crop

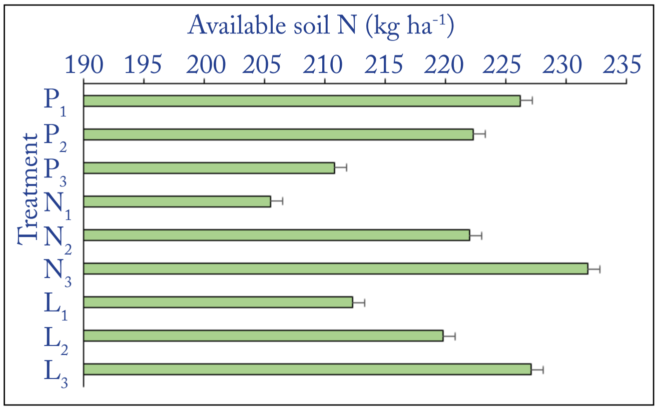

Figure 4: Available nitrogen in soil after harvest of maize crop as influenced by planting density, nitrogen levels and LCC threshold values

Table 2: Nitrogen uptake (kg ha^{-1}) in maize crop as influenced by planting density, nitrogen levels and LCC threshold values

Treatments	P_1	P_2	P_3	N_1	N_2	N_3	L_1	L_2	L_3
N uptake	89.7	109.9	127.1	103.5	108.6	114.7	105	107.7	114.7

N demand leading to higher N uptake due to real time application of nitrogen in five splits at LCC 5. A perusal of data reveals that N uptake was recorded significantly higher with LCC 5, than in LCC 4.5 and LCC 4 during both the years of study. Thus the enhanced values of yield attributing characters witnessed the tendency of nutrient in accelerating growth, photosynthetic activity and translocation efficiency which might have contributed for higher nutrient uptake (Swamy et al., 2016).

4. STATUS OF SOIL AVAILABLE N AFTER HARVEST

The scrutiny of the data revealed that the different planting density, nitrogen levels and LCC threshold values significantly influenced on the available soil nitrogen after harvest of maize crop. Higher soil available nitrogen (Figure 4) was registered with lower planting density of maize i.e., 66,666 plants ha^{-1} (226.2 kg ha^{-1}) followed by 83,333 plants ha^{-1} (223.3 kg ha^{-1}) and 1,11,111 plants ha^{-1} (210.7 kg ha^{-1}). It might be due to absorption and uptake of nutrients at lower planting density because of less competition for nutrients (Rao et al., 2016). Maximum available nitrogen status in soil was recorded with application of 40 kg N ha^{-1} at different splits. Among LCC threshold values, split application of 40 kg N ha^{-1} with LCC threshold 5 recorded significantly higher available soil nitrogen compared with LCC 4.5 and 4. The uptake of N may also be higher due to, frequent application of mineral N besides greater mineralization of native N, as evidenced by significantly higher availability of N in the soils even after harvest of crop under N management through LCC at higher thresholds.

While in respect to interaction effect between planting density and nitrogen levels on available nitrogen in soil was significant during both the years of study and other treatment combinations did not show any significant effect. However, higher available nitrogen was recorded with the combinations of lower planting density along with application higher nitrogen levels (P_1N_3) and it was statistically superior to rest of the treatment combinations. Lower quantity of soil available nitrogen was noticed with higher planting along with application lower nitrogen levels (P_3N_1) (Figure 5).

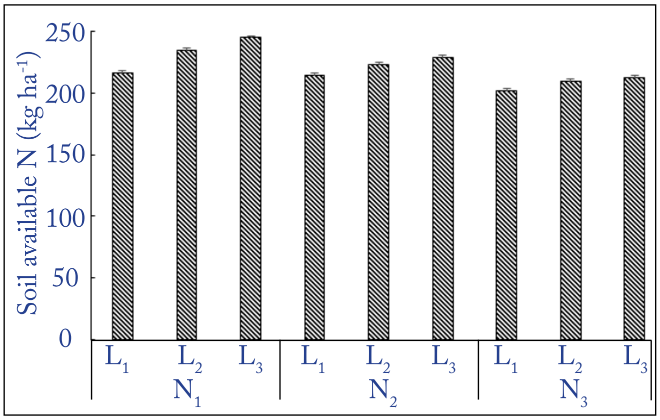

Figure 5: Interaction effect of planting density and nitrogen levels on available soil nitrogen (kg ha^{-1})

5. NITROGEN SAVED

Planting of maize at lower density consumed lower amount of mean nitrogen i.e. 157.8 kg and 166.6 N ha^{-1} in which N saving is 82.2 kg and 73.4 kg N ha^{-1}, respectively. Whereas at higher plant densities total quantity of N required is 182.6 kg and 186.5 kg N ha^{-1} and N saving was 57.4 kg and 53.4 N ha^{-1}, respectively since the recommended dose is 240 kg N ha^{-1} (Table 3). At lower planting density of 66,666 plants ha^{-1}, application of 40 kg N ha^{-1} as top dressing in three and four splits based on LCC threshold 5 resulted in maximum kernel yield with a saving of 60.2 kg N ha^{-1}, during both the years of investigation. Whereas, at planting density of 83,333 plants ha^{-1} top dressing of 40 kg N ha^{-1} in four and five splits using LCC 5 saved 60.1 and 34.0 kg N ha^{-1} during first and second year, respectively. Matching fertilizer N supply with crop demand using threshold LCC shade 5 saved 20–50% fertilizer N (Singh et al., 2011; Swamy et al., 2016).

Table 3: Mean quantity of fertilizer N applied and saved in various treatments based on LCC (pooled data)

		Total quantity of fertilizer N applied and saved (kg ha^{-1})											
		L_1		L_2		L_3		Mean for each treatment combination		Mean N applied		Mean N saved	
		2017–2018	2018–2019	2017–2018	2018–2019	2017–2018	2018–2019	2017–2018	2018–2019	2017–2018	2018–2019	2017–2018	2018–2019
P_1	N_1	140	150	150	165	160	170	150	160	157.8	166.6	82.2	73.4
	N_2	141.5	160	153.2	165	176.5	176.6	157	168.8				
	N_3	153.2	166.6	166.6	166.5	179.8	179.8	166.5	170.9				

Table 3: Continue...

		Total quantity of fertilizer N applied and saved (kg ha^{-1})											
		L_1		L_2		L_3		Mean for each treatment combination		Mean N applied		Mean N saved	
		2017–2018	2018–2019	2017–2018	2018–2019	2017–2018	2018–2019	2017–2018	2018–2019	2017–2018	2018–2019	2017–2018	2018–2019
P_2	N_1	160	150	170	160	180	180	170	163.3	172.6	176	67.4	64.7
	N_2	164.8	164.9	164.9	176.5	188.2	199.9	172.6	180.4				
	N_3	166.4	166.5	179.4	179.8	179.9	206.5	175.2	184.2				
P_3	N_1	160	160	170	170	188.6	190	173.3	173.3	182.6	186.5	57.4	53.4
	N_2	166	176.6	176.5	189.9	190	199.9	177	188.8				
	N_3	179.7	179.9	193.1	193.2	219.9	219.9	197.5	197.6				
Mean for L		159	164.3	169.3	173.4	184.7	191.3						

5. CONCLUSION

Planting density of 1,11,111 plants ha^{-1} supplied with 40 kg N ha^{-1} and top dressing using LCC threshold 5 (LCC 5) along with basal application of 60 kg N ha^{-1} resulted highest yield of hybrid maize.

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