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Improvement of Leaf Chlorophyll Content and Yield of Maize Through Calibration of Optimum Basal and Top Dressing Urea

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A b s t r a c t

The experiment was carried out at the Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, the University of Rajshahi during the period from 1st December 2018 to 20th April 2019 to calibrate basal and top dressing nitrogen fertilizer to improve leaf chlorophyll content and yield of maize. In the field experiment, a split-plot design was used with three replication. This experiment consists of three basal urea application rates (B_1= 50% of the standard dose of nitrogen; B_2= 100% of the standard dose of nitrogen; B_3= 150% of the standard dose of nitrogen) and three topdressing urea application rates ($N_{1=}$ 50% of the standard dose of nitrogen; N_2= 100% of the standard dose of nitrogen; N_3= 150% of the standard dose of nitrogen) Standard irrigation schedule, as well as other cultivation procedures, were followed during the experiment. Digital color image analysis based on Red, Green and Blue (RGB) color models have been used to determine plant Ch and N. both experimental parameters (basal and topdressing urea application rate) have remarkable effects on maize, chlorophyll content, growth characters, physiological characters, yield components and yield performance. Maximum top dressing urea rate N_3, which reduces gradually with the reduction of urea amount. The maximum grain yield (10.48 t ha^{-1}) was observed in N_3, and the maximum stover yield (12.60t ha^{-1}) and biological yield (23.08t ha^{-1}) were found in N_1. The harvest index was non-significant for both basal and top dressing urea rates. From our observation, it was found that nitrogen fertilizer is the most critical material in maize production. It can also suggest that maize leaf can be measured using an algorithm based on RGB, and this value could be a good indicator to determine urea top dressing amount.

Keywords: Chlorophyll content, irrigation schedule , Basal and top dressing.

Introduction

Bangladesh is one of the world's most densely populated countries where 150 million people live within only 147610 square kilometers. Innovative agricultural management systems are a necessity to fulfill the future demand for food, feed, and fiber products while minimizing negative atmospheric, soil, and water quality impact. To meet the increasing demand of the growing population crop field is used intensively where the farm environment is one of the main prerequisites for sustainable crop production. Various types of crops are produced in this country.

Maize (*Zea mays L.*) is one of the oldest and most important crops in the world. It is the highest-yielding grain crop having multiple uses. The average yield of maize in 2003 in the world was 4.47 t ha^{-1} as compared to 3.84 t ha^{-1} for wheat (FAO, 2004). It is the world's third most important cereal crop after wheat and rice grown primarily for grain and secondly for fodder (Panda, 2010). Now maize has become an important cereal crop in Bangladesh.

Maize is the third major crop in Bangladesh. Further, it is grown both in the winter and summer seasons. Its yield is much higher than other crops. Therefore, it has the scope to cover more areas around the year and it can contribute greatly to the food supply for the growing number of people in the country. During the last few years, farmers have adopted greatly the cultivation of composite varieties and hybrids of maize in their farming systems due to many reasons. It is now widely used in animal feeding, and poultry farms and roasted and fried maize are consumed by the people. This results from the demand for increasing maize production in the country. It is one of the cash crops in Bangladesh which has the potential to pull farmers out of poverty. Production of maize can increase the income and employment opportunities of the farmers due to its diversified uses (Moniruzzaman *et al.,* 2009). The average yield of maize in Bangladesh is 6.98 mt. ha^{-1} as compared to 4.06 mt. ha^{-1} and 2.78 mt. ha^{-1} of Boro rice and wheat, respectively (AIS, 2017).

Maize is a highly profitable crop based on its return on investment. Modern inputs and production technology can help farmers to increase income through increased yield and improve their socioeconomic conditions. Maize can help in improving the nutritional status of rural people. Production of maize can increase the income and employment opportunities of the farmers due to its diversified uses (Moniruzzaman *et al.,* 2009). As a result, most of the area of Bangladesh is suitable for maize cultivation.

Maize is more nutritious than rice in terms of protein, phosphorus and carotene content. Fats and mineral contents are also higher. It is rich in Vitamin B and traces elements. Its grain has high nutritive value containing 66.20% starch, 11.10% protein, 7.12% oil and 1.50% minerals. Moreover, it contains 90g carotene, 1.80mg niacin, 0.90 mg thiamine and 0.10mg riboflavin in pure 100g grain (Razzak *et al*., 2022)

Optimum nitrogen fertilization is one of the major factors for the higher production of maize (Devi and Muhammad, 2001). Although nitrogen exists in abundance in the earth's atmosphere, relatively few plants can convert atmospheric nitrogen to a form they can use. Typically, commercial fertilizers contain nitrogen as a supplement for depleted soil. Nitrogen fertilizer is an inorganic fertilizer consisting of nitrous compounds such as urea. It is available in different forms, which can be applied to the surface of the soil by hand or machine. Where the soil has become depleted of its natural nitrogen stores, fertilizers can make up for the deficiency. This is especially important where crops are planted in the same soil each season and additional nutrients are needed for each new crop. The use of nitrogen fertilizers helps to keep nutrient levels at an optimum level, protect against disease and control weeds, resulting in healthier crops and consistent quality and quantity of yields.

The efficient use of N in plant production is an essential goal for crop management. Nitrogen use efficiency (NUE = DM or grain per unit of available N) can be increased by increasing the physiological efficiency (PE = DM per unit of N uptake), recovery efficiency (RE = N uptake per unit of available N), or both. Nitrogen uptake efficiency is highly variable and greatly influenced by the development and morphology of the root system (Moriri *et al*., 2010). Nitrogen supply can affect plant growth and productivity by altering both leaf area and photosynthetic capacity (Akmal *et al*., 2010).

Digital image analysis based on the presence of red, green and blue (RGB) colors of the fully expanded leaves was used to determine plant Ch and N. Many studies used RGB color models to find a correlation with the Ch and N status of plants (Ali *et al*., 2013). Optimal nitrogen fertilization is important for achieving a successful high-yielding maize crop. Equable nitrogen fertilizer management for maize makes good economic sense. Insufficient nitrogen fertilizer inputs result in loss of silage or grain yield. Excessive nitrogen fertilizer inputs blow up profitability and can rush maturity for grain corn (Cheptoyek, 2018). Applying the equable fertilizer nitrogen rate acquires better crop yield and the results are maximum economic return. Proper nitrogen management also makes good environmental sense. Excess nitrogen fertilizer application increase environmental losses of nitrogen including nitrate leaching to groundwater and discharge of nitrous oxides greenhouse gas. Better nitrogen management represents an effective and practical means for producers to reduce greenhouse gas emissions. Therefore, our main aim is to investigate the specific nitrogen dose to improve leaf chlorophyll content, and crop yield and reduce the nitrogen application rate which will be beneficial to farmers as well as for the environment.

The Objectives of the research were: To determine the appropriate nitrogen fertilizer dose for higher yield in maize cultivation. To study the growth, leaf chlorophyll content and yield of maize subjected to the application of different amounts of basal and topdressing nitrogen fertilizer. To maximize agricultural profitability and strengthen the economy of the rural community.

Plant materials and growth condition

The present research was carried out at the Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi, during the period from November 2018 to March 2019 to study the calibration of basal and top dressing nitrogen fertilizer to improve maize growth and yield. In this chapter, the details of the different materials used and methodologies followed during the experiment are presented. Geographically the experimental field is located at 24°22'36" N latitude and 88°38'27" E longitude at an average altitude of 71 ft. above sea level. The experimental area belongs to the subtropical climate under the central southern part of high ranges river floodplain i.e. under the Agro-Ecological Zone-11 (AEZ-11) (Waheeda *et al.,* n.d.) The land of the experimental field was flat, well-drained and above flood level (Medium high land). The soil was sandy loam textured having a pH value of 8.1. the composite soil sample was collected from 0-15cm depth of the experimental plot before applying any fertilizer and was analyzed for physical and chemical properties**.** The experimental field was under a subtropical climate characterized by moderately high temperatures and heavy rainfall during the Kharif season (April to September) and scant rainfall with moderately low temperatures during the rabi season (October to March). The experimental area was previously cropped with jute (*Corchorus olitorous*) in the preceding *Kharif* season. The experiment was carried out with two factors. **Factor 1**: Basal urea application: B_1=50% of the standard basal dose, B_2=100% of the standard basal dose and B_3=150% of the standard basal dose. **Factor 2:** Topdressing urea application: N_1=50% of standard topdressing dose,N_2= 100% of standard topdressing dose,N_3= 150% of standard topdressing dose. The standard application rate of urea in the study area is 550 kg/ha. Thus 182 kg urea per hectare (1/3 of 550 kg/ha) was considered as standard basal urea and the same amount (182 kg/ha) was top-dressed two times in the case of standard topdressing dose. The corresponding ratio was maintained to calibrate other urea combinations.

Crop cultivation and Agronomic management

The land was first opened with a power tiller on 20th October 2018. Later on, the land was plowed and cross-ploughed three times followed by laddering. Individual plots were prepared by repeated spading until the soil achieved a good tilth and was ready for sowing. The weeds and stubbles were removed to clean the land. To supply water, drainage channels were made around the experimental plots. The following fertilizers were used as a general dose in the experimental plots. TSP: 250 kg ha^{-1}, MP: 220 kg ha^{-1}, Gypsum: 250 kg ha^{-1}, Zinc sulfate: 15kg ha^{-1} and Boric acid: 5kg ha^{-1}. Except for urea, whole triple super phosphate (TSP), muriate of potash (MP), zinc sulfate, and boric acid were applied at the time of final land preparation while urea was applied as per experimental treatments. Hybrid maize by variety Syngenta NH-7720 marketed by Syngenta seed international, Bangladesh used in the experiment. Before sowing collected seeds were treated with 4g provax-200 wp kg^{-1} to prevent seeds from attack of seed and soil-borne diseases. Seeds were sown on 10th November 2018 in 70 cm apart rows by hand drilling of a depth of 3-4 cm deep furrows with a country plough and three seeds were placed within the furrow to establish one plant 25 cm apart. The seeds were sown continuously in the furrow at the rate of 30 kg ha^{-1}. After sowing seeds were covered by soil with little pressure by hand. The seedlings emerged within 6-8 days after sowing (DAS). Necessary gap filling was done at 14 DAS maintaining the desired number of the plant (s). Weeding was done three times, at 30, 45and 70 DAS. Thinning was done at 14 DAS. Only one healthy seedling was kept and the rest were thinned out. Earthing up was done by spade at 45 DAS to prevent the lodging of plants. The plot was irrigated four times during the growing period of the crop. The irrigation was applied at 15 DAS, 35 DAS, 55 DAS and 85 DAS. Drainage was done when necessary by using drainage channels. Leaf blight disease was found in the experimental field. It was not observed in the economic threshold level (ETL). This disease was controlled by spraying Tilt-250 EC @2 ml L^{-1}. Malathion was applied to control aphids. The damage to maize crops by Jackals at booting and young cob stage was a big problem in the experimental area. Another greater problem in this locality was the damage of mature grains at the full maturity cob stage by parakeets. Therefore, from early morning to evening and the whole night, 2 guards were appointed from the booting stage to the maturity stage to protect the crop from probable damage by parakeets, Jackals and birds. For collecting data on plant growth, yield components and yield, three plants were randomly selected and marked with bamboo sticks in each plot. The field was under constant observation. Crop production was satisfactory throughout the experiment. At maturity, the experimental crops were harvested plot-wise on 22nd March 2019 Before harvesting plant samples were selected randomly and uprooted from each plant for data recording. The harvested crops from each plot were bundled separately, tagged and brought to the clean threshing floor. The same procedure was followed for the sample plant (3 plants from each plot). Harvested crops were sun-dried. Then shelled and grains were cleaned properly plot by plot. Grains and stover were sundried thoroughly before their weights were recorded. Grain yield was adjusted at 14% moisture content. Grain and stover yields were then converted into t ha^{-1}. Data on the following plant characters, yield and yield components were collected from the sample of each plot. Digital image analysis based on red, green and blue (RGB) color model was used to determine leaf chlorophyll content. Many studies used RGB color models to find a correlation with the Ch and N status of plants (Ali *et al*., 2013). Images of the leaf samples were scanned using HP Scanjet G2410. Scanned images were then opened with Microsoft Paint software. To measure leaf greenness, it is necessary to determine the presence of those colors from the leaf image. Another computer application, RGB Picker was used to determine the composition of red, blue and green colors in the leaf image (Figure 1b). The following formula was used for nitrogen content determination according to (Ali *et al*., 2013), ChN RGB= G − R/2 − B/2.

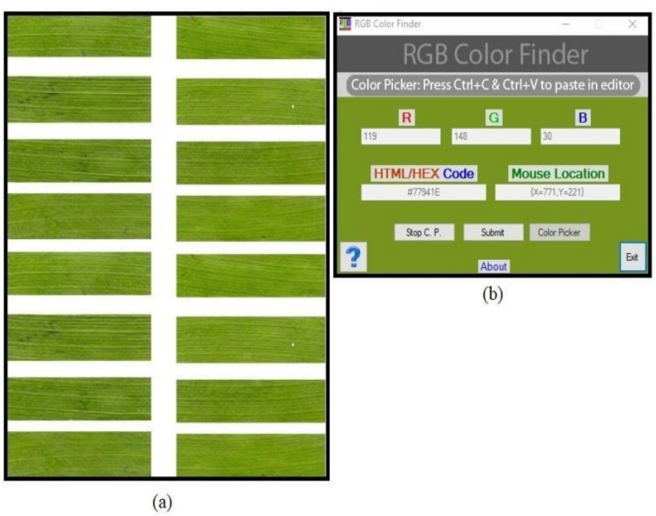

Figure 1:. Image of the scanned leaf. (b) Measurement of the composition of red, blue and green colors using an RGB color finder.

Five randomly chosen plants from the middle of the plot ($1m^2$) were used to get information about maize's different characteristics. Finally, grain weights were taken on an individual plot basis at a moisture content of 13% and converted into kg ha^{-1}. Data on morpho-physiological, yield and yield components were also collected at harvest.

Statistical procedure

The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the mean differences were adjudged with Duncan's Multiple Range Test (DMRT) using the statistical computer package program, MSTAT- C (Gomez and Gomez, 1984). using STATVIEW software the data were statistically evaluated using the analysis of variance technique, and the mean differences were determined using Duncan's multiple range test (DMRT).

Results

The experimental results obtained in this study regarding the effect of basal and top dressing nitrogen fertilizer (urea) rate and their interaction on growth, physiological responses and yield of maize (*Zea mays L.*) were represented. The detailed results on plant characteristics such as growth parameters, leaf chlorophyll content, yield and yield components are shown in Tables 1 to 3. In this chapter different observations were made to fulfill the objectives of the research work.

Plant height of maize plants for the application of basal urea was measured on 30, 60, 90 and 120 DAS. Plant height was significantly influenced by basal urea rate in most of the observations except 30 DAS (Table 1). At 30 DAS, maximum plant height (56.03 cm) was observed both in 50% (B_1) and 150% (B_3) of basal urea application and the lowest plant height (51.69 cm) was in 100% of basal urea (B_2). At 60 DAS, the highest plant height was found (83.73cm) in B_3 and it reduced moderately by 6.04% in B_2 and significantly by 14.71% in B_1. At 90 DAS, the highest plant height was found (125.01cm) in B_3 and it reduced slightly by 4.53 % in B_2 and significantly by 15.11% in B_1. At 120 DAS, the highest (164.73cm) plant height was found in B_3 which reduced significantly by 7.45% and 17.15% in B_2 and B_1 respectively. The plant height of maize was significantly influenced by the application of top dressing urea rate at 60, 90 and 120 DAS (Table 1). At 30 DAS, the maximum plant height (55.69 cm) was found in N_1 (50% of a standard top dressing of urea) while the minimum (50.58 cm) was in N_2 (100% of a standard top dressing of urea). At 60 DAS, the highest (90.93cm) plant height was found in N_3 which decreased significantly by 14.93% and 28.63% in N_2 and N_1, respectively. At 90 DAS, the highest (134.46cm) plant height was found in N_3 which decreased significantly by 19.80% and 29.51% in N_2 and N_1, respectively. At 120 DAS, the highest (172.45cm) plant height was found in N_3 which decreased significantly by 11.24% and 25.69% in N_2 and N_1, respectively. Plant height was not statistically significant due to the interaction between basal and topdressing urea application (Table 1). At 30 DAS, the maximum plant height (61.70 cm) was observed in the combination of B_2 with N_1 and the minimum value (47.01 cm) was found in the combination of B_1 with N_3. At 60 DAS, the highest plant height (100.45 cm) was found for the interaction of B_3 with N_3 and the lowest plant height (61.18 cm) was found for the interaction of B_1 with N_1. At 90 DAS, the highest plant height (146.60 cm) was found for the interaction of B_3 with N_3 and the lowest plant height (85.51 cm) was observed for the interaction of B_1 with N_1. At 120 DAS, the highest plant height (193.51 cm) was observed for the interaction of B_3 with N_3 and the lowest plant height (118.94 cm) was noticed for the interaction of B_1 with N_1.

The total leaf area (cm^2) was influenced significantly due to the application of basal urea rate which was presented in (Table 1). The highest leaf area of maize (2748.17 cm^2) was found in the maximum basal urea application rate or B_3 which reduced slightly by 2.30% in B_2 and significantly by 16.29% in B_1. The total leaf area (cm^2) presented in (Table 1), differed significantly due to the application of the top dressing urea rate. The highest leaf area

Table 1. Effect of basal, top dressing urea rate and interaction effect on plant height (cm)and total leaf area(cm^2) of maize.

Basal urea rate	Plant height (cm)				Total leaf area (cm^2)
	30(DAS)	60(DAS)	90 (DAS)	120(DAS)	
B_1	51.69	71.41 b	106.12 b	136.47 b	2300.36 c
B_2	56.03	78.67 a	119.34 a	152.45 a	2685.05 b
B_3	51.69	83.73a	125.01 a	164.73 a	2748.17 a
LS	NS	0.05	0.01	0.05	0.01
Top dressing urea rate					
N_1	55.69	64.89c	94.74c	128.14c	2079.79c
N_2	50.58	78.00b	121.27b	153.05b	2630.14b
N_3	53.13	90.93a	134.46a	172.45a	3023.65a
LS	NS	0.01	0.01	0.01	0.01
Interaction effect of basal urea rate × top dressing urea rate					
B_1N_1	56.35	61.18	85.51	118.94	1757.66
B_1N_2	51.69	72.85	111.95	140.24	2434.4
B_1N_3	47.01	80.21	120.91	150.2	2709.02
B_2N_1	61.7	67.94	101.87	135.21	2337.69
B_2N_2	48.03	75.93	120.27	148.51	2656.87
B_2N_3	58.35	92.15	135.87	173.64	3060.57
B_3N_1	49.02	65.54	96.84	130.27	2144.04
B_3N_2	52.02	85.21	131.58	170.41	2799.14
B_3N_3	54.03	100.45	146.6	193.51	3301.35
LS	NS	NS	NS	NS	NS
CV%	19.03	6.89	4.91	7.13	4.33

Mean followed by the same letters or without a letter in a column do not differ (as per DMRT).DAS= Days after sowing; LS= Level of significance; CV= Co-efficient of variation; NS= Non-significant; B1= 50% of the standard dose of nitrogen; B2= 100% of the standard dose of nitrogen; B3= 150%; N1=50% of the standard dose of nitrogen; N2= 100% of the standard dose of nitrogen; N3=150% of the standard dose of nitrogen.

(3023.65 cm^2) was found in the maximum top dressing urea application rate (N_3) which decreased significantly by 13.01% and 31.21% for N_2 and N_1, respectively. Leaf area was not statistically significant due to the interaction between basal and top dressing urea application in (Table 1). The highest value (3301.35cm^2) was found for the interaction in B_3 with N_3 and the lowest value (1757.66 cm^2) was observed for the interaction in B_1 with N_1.

It was observed that total dry matter production increased day by day with the progress of the age of the plant. The total dry matter (gm^{-2}) of maize for the application of basal urea was measured on 30, 60, 90, 120 and 140 DAS were presented in Table 2. At 30 DAS, Total dry matter production was found maximum (3.78 gm^{-2}) for 100% basal urea application rate (B_2) and minimum (2.32 gm^{-2}) for 150% basal urea application rate (B_3). At 60 DAS, total dry matter (TDM) production was influenced significantly by the basal urea application rate. The highest total dry matter was found (38.65 gm^{-2}) in B_3 that reduced moderately by 6.80 % in B_2 and significantly by 28.95% in B_1. At 90 DAS, the highest total dry matter (TDM) production was found (94.31 gm^{-2}) in B_3 that reduced slightly (3.18%) in B_2 and significantly by 17.29% in B_1. At 120 DAS, the highest TDM was found (158.40 gm^{-2}) in B_3 which reduced slightly (3.67 %) in B_2 and significantly by 27.98 % in B_1. At 140 DAS, the highest total dry matter (TDM) production was found in B_3 (233.79 gm^{-2}) which reduced significantly by 12.67% and 21.42% in B_2 and B_1, respectively. Total dry matter differed significantly due to the application of top dressing urea at 60, 120 and 140 DAS (Table 2). At 30 DAS, the highest TDM was found (3.43 gm^{-2}) for N_2 and the lowest (2.46 gm^{-2}) was found in N_1. At 60 DAS, the highest (42.56 gm^{-2}) TDM was found in N_3 which decreased significantly by 21.61% and 38.41% in N_2 and N_1, respectively. At 90 DAS, the highest (103.29 gm^{-2}) TDM was found in N_3 which decreased significantly by 13.05% and 31.72% in N_2 and N_1, respectively. At 120 DAS, the highest (156.40 gm^{-2}) total dry matter (TDM) was found in N_3 which decreased significantly by 8.12% and 20.01% in N_2 and N_1, respectively. Finally, at 140 DAS, the highest (228.23 gm^{-2}) TDM was found in N_3 which reduced significantly by 9.22% and 18.40% in N_2 and N_1, respectively. The interaction effect between basal and top dressing urea application on total dry matter (TDM) production was not differed significantly (Table 2). At 30 DAS, the highest total dry matter (4.68 gm) was observed for the interaction in B_2 with N_2 and the lowest value (1.71 gm) was recorded for the interaction in B_3 with N_1. At 60 DAS, the highest total dry matter (51.24 gm^{-2}) was observed for the interaction in B_3 with N_3 and the lowest value (22.27 gm^{-2}) was recorded for the interaction in B_1 with N_1. At 90 DAS, the highest total dry matter (109.82 gm^{-2}) was observed for the interaction in B_3 with N_3 and the lowest value (56.28 gm^{-2}) was recorded for the interaction in B_1 with N_1. At 120 DAS, the highest total dry matter (177.24gm^{-2}) was observed for the interaction in B_3 with N_3 and the lowest value (97.10 gm^{-2}) was noticed for the interaction in B_1 with N_1. At 140 DAS,the highest total dry matter (246.00 gm^{-2}) was observed for the interaction in B_3 with N_3 and the lowest value (152.17 gm) was noticed for the interaction in B_1 with N_1.

The chlorophyll content of maize plants for the application of basal urea was measured on 30, 60, 90 and 120 DAS were presented in table 2. The Chlorophyll content differed significantly due to the application of basal urea rate at 30, 60,120 and 90 DAS. At 30 DAS, the highest chlorophyll content was found (51.13) in B_3 reduced slightly by 3.40% in B_2 and significantly by 19.22% in B_1. At 60 DAS, the highest chlorophyll content was found (51.20) in B_3 that reduced moderately by 10.33% in B_2 and significantly by 22.98 % At 90 DAS, the highest chlorophyll content was found (48.80) in B_3 that reduced slightly 4.97% in B_2 and significantly 17.09% in B_1. At 120 DAS, the highest chlorophyll content was

Table 2. Effect of basal, top dressing and Interaction urea rate on total dry matter (TDM) gm-2 and chlorophyll content (ChNRGB) of maize

Basal urea rate	Total dry matter (TDM) gm^{-2}					Chlorophyll content (ChN_{RGB})			
	30 (DAS)	60 (DAS)	90 (DAS)	120 (DAS)	140 (DAS)	30 (DAS)	60 (DAS)	90 (DAS)	120(DAS)
B_1	2.56	27.46 b	78.00 b	114.07 b	183.71c	40.59b	39.43b	40.46b	39.26c
B_2	3.78	36.06 a	91.31 a	152.58 a	204.15b	48.54a	45.91a	46.37a	44.96b
B_3	2.32	38.65 a	94.31 a	158.40 a	233.79a	51.13a	51.20a	48.80a	49.77a
LS	NS	0.01	0.01	0.01	0.01	NS	0.01	0.01	0.05
Top dressing urea rate									
N_1	2.46	26.21c	70.52c	124.96c	186.23c	31.55c	34.04c	36.04c	36.52c
N_2	3.43	33.36b	89.81b	143.69b	207.18b	47.37b	43.24b	44.48b	43.27b
N_3	2.76	42.56a	103.29a	156.40a	228.23a	60.13a	57.26a	53.89a	53.48a
LS	NS	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Interaction effect of basal urea rate × top dressing urea rate									
B_1N_1	2.07	22.27	56.28	97.1	152.17	27.5	30.45	30.94	31.72
B_1N_2	2.98	26.48	84.12	117.47	184.06	44.83	37.56	42.45	41.5
B_1N_3	2.64	33.63	93.61	127.64	214.91	49.44	50.28	48	44.55
B_2N_1	3.61	28.96	80.89	140.79	182.84	37.39	36.67	40.39	39.78
B_2N_2	4.68	36.29	86.6	152.63	205.83	45.95	43.45	44.83	43.003
B_2N_3	3.05	42.83	106.44	164.33	223.79	62.28	57.61	53.89	52.11
B_3N_1	1.71	27.4	74.38	137	223.67	29.78	35	36.79	38.06
B_3N_2	2.64	37.32	98.73	160.97	231.67	54.94	54.72	47	46.34
B_3N_3	2.61	51.24	109.82	177.24	246	68.67	63.89	59.78	63.78
LS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV%	58.12	11.65	6.86	5.82	5.78	8.13	9.31	8.66	8.91

Mean followed by the same letters or without a letter in a column do not differ (as per DMRT).DAS= Days after sowing; LS= Level of significance; CV= Co-efficient of variation, NS= Non-significant; B_1= 50% of the standard dose of nitrogen; B_2= 100% of the standard dose of nitrogen; B_3= 150% of the standard dose of nitrogen; N_1= 50% of the standard dose of nitrogen; N_2= 100% of the standard dose of nitrogen; N_3= 150% of the standard dose of nitrogen.

found (49.77) in B_3 which decreased significantly (9.66%) and (21.11%) in B_2 and B_1, respectively. Considering the top dressing urea rate, chlorophyll content was found to be significant at 30, 60, 90 and 120 DAS were presented in table 2. At 30 DAS, the highest chlorophyll content was found (60.13) in N_3 which decreased significantly (19.20%) and (47.53%) in N_2 and N_1, respectively. At 60 DAS, the highest chlorophyll content was found (57.26%) in N_3 which decreased significantly (24.48%) and (40.55%) in N_2 and N_1, respectively. At 90 DAS, the highest chlorophyll content was found (53.89) in N_3 which decreased significantly (15.19%) and (33.12%) in N_2 and N_1, respectively. At 120 DAS, maximum chlorophyll content was found (53.48) in N_3 which decreased significantly (19.09%) and (31.71%) in N_2 and N_1, respectively. Chlorophyll content was not statistically significant due to the interaction between basal and topdressing urea application in table 3. At 30 DAS, the highest chlorophyll content of maize (68.67) was found for the interaction in B_3 with N_3 and the lowest (27.50) was recorded for the interaction in B_1 with N_1. At 60 DAS, the highest chlorophyll content of maize (63.89) was found in B_3 with N_3 and the lowest (30.45) in B_1 with N_1. At 90 DAS, the highest chlorophyll content of maize (59.78) was found in B_3 with N_3 and the lowest (30.94) in B_1 with N_1. At 120 DAS, the highest chlorophyll content of maize (63.78) was found in B_3 with N_3 and the lowest (31.72) in B_1 with N_1.

The cob length (cm) of maize is presented in table 3. which was not influenced significantly by basal urea rates. The cob length of maize was maximum (10.59 cm) in the highest basal urea application rate (B_3) while minimum (10.26 cm) in the lowest basal urea application rate (B_1). Cob length differed non-significantly due to the application of top dressing urea rate which was presented in table 3. The cob length of maize was maximum (10.56 cm) in the highest basal urea application rate (N_3) while minimum (10.31 cm) in the lowest basal urea application rate (N_1). Interaction between basal and top dressing urea application was not differed significantly shown in table 3. The highest cob length (10.64 cm) was observed for the interaction in B_3 with N_3 and the lowest value (9.85 cm) was recorded for the interaction in B_1 with N_1. The number of grains per cob of maize presented in table 3 was significant for basal urea rates. The highest number of grains per cob of maize was found (304.20) in the maximum basal urea application rate (B_3) which decreased significantly by 4.02% and 12.06 % in B_2 and B_1, respectively. The number of grains per cob of maize was affected significantly due to the application of top dressing urea rate shown in table 3. The highest number of grains per cob was found (319.75) in maximum top dressing create (N_3) which decreased significantly by 8.47% and 21.41 % in N_2 and N_1, respectively. Interaction between basal and top dressing urea application has not differed significantly. The highest number of grains per cob^{-1} (340.45) was observed for the interaction of B_3 and N_3 and the lowest value (224.34) was recorded for the interaction of B_1 and N_1.1000 grain weight (gm) of maize was presented in table 3. differed significantly due to application of basal urea rates. The highest 1000 grain weight (gm) of maize was found (290.64 gm) in B_3 reduced slightly (1.01%) in B_2 and significantly by 16.07 % in B_1. 1000 grain weight (gm) of maize differed significantly due to the application of topdressing urea rate which is presented in table 3. The highest 1000 grain weight (gm) of maize was also found (320.28 gm) in the maximum top dressing urea amount (N_3) and the value reduced significantly by 10.60% and 32.60% in N_2 and N_1, respectively. Interaction between basal and top dressing

Table 3. Effect of basal, top dressing and Interaction urea rate on yield components and yield of maize.

Basal urea rate	Cob length (cm)	No. of grains cob^{-1}	1000 grain Weight (g)	Grain Yield (t ha-1)	Stover Yield (t ha-1)	Biological yield (t ha-1)	Harvest Index (%)
B_1	10.28	267.49c	243.91b	9.05b	10.14b	19.20b	47.5
B_2	10.47	291.97b	287.70a	9.74a	12.24a	21.99a	44.28
B_3	10.59	304.20a	290.64a	10.04a	12.11a	22.17a	45.42
LS	NS	0.05	0.01	0.05	0.01	0.01	NS
Top dressing urea rate							
N_1	10.31	251.27c	215.71c	8.62c	10.29b	18.92b	46.11
N_2	10.45	292.64b	286.26b	9.74b	11.61a	21.35a	45.61
N_3	10.56	319.75a	320.28a	10.48a	12.60a	23.08a	45.48
LS	NS	0.01	0.01	0,01	0.05	0.05	NS
Interaction effect of basal urea rate × top dressing urea rate							
B_1N_1	9.85	224.34	167.68	7.77	7.57	15.35	50.68
B_1N_2	10.48	278.23	271.38	9.19	11.06	20.25	45.38
B_1N_3	10.46	299.9	292.68	10.2	11.8	21.99	46.46
B_2N_1	10.45	270	253.04	8.95	12.12	21.07	42.48
B_2N_2	10.37	287.01	284.01	10.05	12.21	22.27	45.16
B_2N_3	10.58	318.9	326.06	10.22	12.4	22.63	46.19
B_3N_1	10.63	259.48	226.41	9.15	11.17	22.33	45.16
B_3N_2	10.51	312.67	303.4	9.97	11.57	21.55	46.3
B_3N_3	10.64	340.45	342.11	11.02	13.59	24.62	44.8
LS	NS	NS	NS	NS	NS	NS	NS
CV%	9.1	4.18	3.4	15.06	8,56	7.58	6.74

Mean followed by the same letters or without a letter in a column do not differ (as per DMRT).DAS= Days after sowing; LS= Level of significance; CV= Co-efficient of variation, NS= Non-significant; B_1= 50% of the standard dose of nitrogen; B_2= 100% of the standard dose of nitrogen; B_3= 150% of the standard dose of nitrogen; $N_{1=}$ 50% of the standard dose of nitrogen; N_2= 100% of the standard dose of nitrogen; N_3= 150% of the standard dose of nitrogen.

urea application has not differed significantly. The highest 1000 grain weight (g) (342.11 g) was observed for the interaction in B_3 with N_3 and the lowest (167.68 g) was for the interaction in B_1 with N_1. The grain yield of maize is presented in table 3. Which was influenced significantly by basal urea rates. Grain yield was found highest (10.04 t ha^{-1}) in the highest basal urea application rate (B_3) which reduced slightly by 2.98% in B_2 and significantly by 13.40% in B_1. The grain yield of maize differed significantly due to the application of top dressing urea rate which is shown in table 3. The highest grain yield (10.48 t ha^{-1}) was found in N_3 which was reduced significantly by 7.06% and 17.70 % in N $_2$ and N_1, respectively.

Much previous research (Modhej *et al*., 2008) claimed that nitrogen (N) fertilizer has played a significant role in increasing crop yield. The interaction effect between basal and top dressing urea application did not differ significantly. The highest grain yield (11.02 t ha^{-1}) was observed for the interaction in B_3 with N_3 and the lowest value (7.77 t ha^{-1}) was recorded for the interaction in B_1 with N_1. The Stover yield of maize is presented in table 3 and was influenced significantly by basal urea rates and the value was found highest (12.24 t ha^{-1}) in B_2 that reduced slightly to 0.81% in B_3 and significantly19.20% in B_1. The Stover yield of maize differed significantly due to the application of top dressing urea rate which is shown in table 3. Stover yield was also found maximum with (12.60 t ha^{-1}) top maximum top dressing urea amount N_3 which increased significantly by 7.85 and 18.30 % in N $_2$ and N_1 respectively. Interaction between basal and topdressing urea application did not differ significantly**.** The highest stover yield (13.59 t ha^{-1}) was observed in the interaction of B_3 with N_3 and the lowest value (7.57 t ha^{-1}) was recorded in the interaction of B_1 with N_1. The biological yield has differed significantly for basal urea rates are presented in table 3. The biological yield was found maximum (22.17 t ha^{-1}) for the highest basal urea application rate (B_3) and that reduced slightly to 0.81% in B_2 and significantly 13.30% in B_1. The biological yield of maize differed significantly due to the application of top dressing urea rate which was presented in table 3. The highest biological yield (23.08 t ha^{-1}) was found with maximum top dressing urea (N_3) and that reduced marginally by 7.49% in N_2 and significantly by 18.02 % in N_1. Interaction between basal and topdressing urea application did not differ significantly. The highest biological yield (24.62 t ha^{-1}) was observed for the interaction of B_3 and N_3 and the lowest biological yield (15.35 t ha^{-1}) was recorded for the interaction of B_1 with N_1. The harvest index was not differed significantly due to basal urea application rates in table 3. The highest harvest index (47.50 %) was found for 50% of the recommended dose of basal urea application (B_1) and the lowest harvest index (45.28 %) was found in B_3 (150% of the recommended dose of basal urea application). The harvest index of maize was not differed significantly due to the application of top dressing urea rate which was presented in table 3. Considering urea top dressing rates the highest harvest index (46.11%) was in N_1 and the lowest harvest index (45.48%) was found in N_3. The interaction effect between basal and top dressing urea application rate was not differed significantly (table 3). The highest harvest index (50.68) was observed in the interaction of B_1 with N_1 and the lowest value (44.80) was recorded in the interaction of B_3 with N_3.

Conclusion

From our observation, it was observed that both experimental parameters (basal and top dressing urea application rate) have ordinary effects on maize growth, leaf chlorophyll content, yield components and yield performance.

Different growth parameters such as plant height(cm), total leaf area(cm^2) and total dry matter (g); physiological characters such as chlorophyll content and yield contributing characters like cob length(cm), number of grain cob^{-1}, 1000 grains weight (g), grain yield (t ha^{-1}) and biological yield (t ha^{-1}) was found higher with maximum basal urea application rate (B_3). Stover yield (12.24 t ha^{-1}) was found higher maximum basal urea application rate (B_2).

Results also revealed that most of the growth characteristics such as plant height (cm), leaf area (cm^2) total dry matter (gm^{-2}) physiological characteristics such as chlorophyll content and yield contributing characters like cob length (cm), number of grains per cob, 1000 grain weight (gm), grain yield (t ha^{-1}), stover yield (t ha^{-1}) and biological yield (t ha^{-1}) was found highest numerical data in maximum top dressing urea application rate (N_3).

The interaction effect of basal and top dressing urea application rate was not significant. The highest grain yield (11.02 t ha^{-1}), stover yield (13.59 t ha^{-1}) and biological yield (24.62 t ha^{-1}) were found for the combination of maximum basal urea application rate (B_3) with maximum topdressing urea application rate (N_3).

Based on our findings it can be stated that nitrogen is the most necessary nutrient element in maize production. Basal area is important for initial growth parameters and it produced maximum stover yield whereas topdressing urea is responsible for maize growth in the reproductive stage. Soils in the area might be facing less amount of nitrogen thus maize required additional (150% of standard recommendation) urea fertilizer. Further research should consider the economic and environmental aspects of additional urea application in the study area.

Conflict of interest

There is no conflict of interest among the authors.

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