International Journal for Asian Contemporary Research (2022), Volume 2, Number 2, Page 50-57

H&N Publications INTERNATIONAL

ISSN(e): 2789-4231 & ISSN (p): 2789-4223

International Journal for Asian Contemporary Research

www.ijacr.net

Research Article **Open Access**

Precision Nitrogen Management in Corn (*Zea mays* L.) Using Algorithm Based on the RGB Color Codes by Digital Imaging

Abdur Razzak[1], Bitopi Biswas[1], Tariful Alam Khan[1], Nilufar Yasmin[1], A M Shahidul Alam[1] and M Robiul Islam[1]*

[1]Farming Systems Engineering Laboratory, Department of Agronomy and Agricultural Extension, Rajshahi University, Bangladesh.

Article info

Received: 17 July 2022
Accepted: 20 August 2022
Published: 01 September 2022
Available in online:
01 September 2022

***Corresponding author:**
✉ mrislam@ru.ac.bd

Abstract

The study was carried out in the experimental field of the Department of Agronomy and Agricultural Extension, Rajshahi University, during the period from November 2017 to March 2018, to evaluate the precision nitrogen management in corn using an algorithm based on the RGB color code by digital imaging. The field experiment was set up using a split-plot experimental design with three replications. The experiment consists of three basal urea application rates (S_1=100% of the standard basal dose of N; S_2=75% of the standard basal dose of N, and S_3=50% of the standard basal dose of N) and three topdressing urea application rates (N_1=150% of standard topdressing dose of N; N_2=100% of the standard topdressing dose of N and N_3=50% of standard topdressing dose of N). Standard irrigation and other cultivation procedures were followed during the experiment. Considering different physiological responses, yield components, and yield of corn, it was found that the highest performance was noted for maximum top dressing urea rate (N_1), which reduced gradually with the reduction of urea amount. The highest grain yield (9.61 t ha-1) was observed in N1, which was significantly reducedby 6.14 % for N_2 and 9.26 % for N_3. The highest stover yield (14.40 t ha^{-1}) and biological yield (24.01 t ha^{-1}) was found with N_1. Harvest index (HI) was non-significant for both basal and top dressing urea application rate. The interaction between the basal and top dressing urea application rates had no discernible impact on physiological responses, yield-contributing traits, or maize yield.Our observations show nitrogen is the most important nutrient for maize productivity. While topdressing urea is in charge of maize development during the reproductive stage, basal urea is crucial for initial growth characteristics and hence delivers the highest stover yield.

Keywords: Corn, Nitogen management, Color code and Digital imaging.

Introduction

Bangladesh is a developing agricultural nation. Most of her population relies on agriculture directly or indirectly for their living. Innovative agricultural management techniques are required to meet future demand for food, feed, and fiber products while limiting the detrimental effects on air, soil, and water quality. This agriculture sector concerns the Bangladeshi government a lot. For the past few years, a sizeable percentage of the annual budget has constantly been set aside for the sector's development. The government has also been introducing various initiatives to increase agricultural output. Bangladesh, by birth, has highly fertile ground where different crops thrive swiftly (Amanullah *et al*., 2008). As a result, this nation produces a wide range of crops. One of the most crucial food grains worldwide is maize, especially in developing countries like Bangladesh (Chandra sekhara, 2009). After rice and wheat, it is the third-most significant cereal crop farmed primarily for grain and fodder (Nelson, 2005). Due to its various uses, maize production can enhance farmers' revenue and job options (Moniruzzaman *et al*., 2009). In Bangladesh, the average yield of maize is 6.98 mt. ha^{-1}, compared to 4.06 mt. ha^{-1} and 2.78 mt. ha^{-1} for the corresponding yields of boro rice and wheat (AIS, 2017).

The maize crop has enormous potential to become one of the primary food sources for the world's rapidly growing population. In every manner, the maize plant is advantageous. Green corn cobs are used as food after being roasted or cooked in water. Popcorn is frequently found in snacks. Its grain is exceptionally nutrient-dense, with 1.50 % minerals, 7.12 % oil, 11.10 % protein, and 66.20 % starch.

Additionally, there are 90g of carotene, 1.80 mg of niacin, 0.90 mg of thiamine, and 0.10 mg of riboflavin per 100g of pure maize grain (Chowdhury and Islam, 1993). Following the cob's harvest, the

Link to this article: https://www.ijacr.net/article/33/details

stem's fibrous roots and dry portion are burned as fuel, while the plant's top green portion is used as cattle fodder. Grain is the primary ingredient in feed for poultry and cattle. Businesses use maize to produce a number of products, including cornflakes and chips, corn oil, starch, adhesives, and medications. In Bangladesh, people see maize as either animal feed or food for the poor. However, maize is a widespread food in other countries (e.g. Indonesia, Mexico, Chile, Kenya, Central America and Zimbabwe). It is also less expensive than rice. The country's requirement for maize is anticipated to increase as more fish, poultry, and dairy farms are built. About 174 million hectares of land are used to produce about 925 million tons of grain annually from maize (Kumar *et al*., 2014). As a result, it is the cereal with the highest production. The Food and Agriculture Organization (FAO) of the United Nations (2014) estimates that the demand for maize for human and animal consumption will increase by nearly 300 million tons by 2030, not including the increased demand for biofuel production. In addition, the population of Bangladesh will increase to 223 million by 2030, which will require 48.0 million tons of food grains (Karim et al., 1990). Maize grain also includes 0.10 mg of riboflavin, 0.90 mg of thiamine, 1.80 mg of niacin, and 90 mg of carotene per pure 100g of grain (Chowdhury and Islam, 1993).

The green top of the plant is used to make corn, which is then harvested, and the dried stem and fibrous roots are utilized for fuel. Grain is a significant component of animal and poultry feed. Additionally, businesses use maize to produce corn oil, starch, adhesives, medications, and a variety of food items, including corn flakes and chips. In Bangladesh, people view maize as either food for the impoverished or as animal feed. Nevertheless, maize is a common diet in other nations (e.g. Indonesia, Mexico, Chile, Kenya, Central America and Zimbabwe). It is also less expensive than rice. With the construction of new hen, dairy, and fish farms, the demand for maize in the nation is likely to continue to rise.

In Bangladesh, the area used for growing maize and its output increase daily (BARI, 2011). Increased input use, better pest control, and technical advancements, among other things, have all contributed to a rise in maize yield (Gulati and Dixon, 2008).

For crop management, practical N usage in plant production is essential. Increases in physiological efficiency (PE = DM per unit of N uptake), recovery efficiency (RE = N uptake per unit of available N), or both can boost nitrogen usage efficiency (NUE = DM or grain per unit of available N). However, the root system's growth and morphology significantly impact nitrogen uptake efficiency and is very changeable (Moriri *et al*., 2010). Therefore, digital colour image analysis based on RGB (Red, Green and Blue) colour models has been used to determine plant Ch and N.

Numerous research has examined the relationship between Ch and N plant states using RGB color models (Ali *et al*., 2013). To identify Ch and N levels in maize in field conditions, a novel algorithm based on the RGB color model is being developed in this research. We chose to take leaf images using a scanner instead of most currently used image processing techniques, which employ digital cameras to take pictures. Angle, distance, and lighting variability may be lessened with a scanner. Using RGB color picker software, we analyzed the obtained photos and determined the leaf contour before averaging the green (G), red (R), and blue (B) values of the leaf pixels. Given that estimating both Ch and N requires green, we recommend the following formula. (Ali *et al*., 2013):

$$ChN_{RGB} = G - R/2 - B/2$$

Sound nitrogen management for corn makes good economic sense. Optimal nitrogen fertilization is essential for a successful, high-yielding corn crop. Inadequate nitrogen inputs result in loss of silage or grain yield. Using the optimal fertilizer nitrogen rate results in a high crop yield and a high economic return. Good nitrogen management is also beneficial to the environment. Excess nitrogen application increases nitrogen losses to the environment, including nitrate leaching into groundwater and nitrous oxide emissions, a greenhouse gas. Good nitrogen management is a practical and effective way for producers to reduce greenhouse gas emissions. Therefore present aims to investigateprecision nitrogen management in corn (*Zea mays* L.) using an algorithm based on the RGB (Red, Green and Blue) colour code. The present research aims to investigateprecision nitrogen management in corn (*Zea mays* L.) using an algorithm based on the RGB (Red, Green and Blue) colour code.

Materials and Methods

Plant materials and growth condition

The research was carried out at the Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi, during the period from November 2017 to March 2018 to study the precision nitrogen management in maize using an algorithm based on the RGB (Red, Green, and Blue) color codes. 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 levels. The experimental area belongs to the subtropical climate under the Central Southern Part of the High Ganges River floodplain, i.e., under the Agro-Ecological Zone-11 (AEZ-11). The land of the experimental field was flat, well-drained and above flood level (Medium high land). The soil was sandy loam textured, having pH value of 8.1.The experimental area was previously cropped with jute (*Corchorus olitorous*) in the preceding *kharif* season.

Experimental treatments

The experiment was carried out with two factors. Factor 1: Three basal urea applications,i.e. S_1=100% of the standard basal dose of N, S_2=75% of the standard basal dose of N and S_3=50% of the standard basal dose of N. Factor 2:Three topdressing urea applications,i.e. N_1=150% of the standard topdressing dose of N, N_2=100% of the standard topdressing dose of N and N_3=50% of the standard topdressing dose of N.The experiment was laid out in split-plot design with three replications placing basal urea rates in the main plot and topdressing urea amount in the split-plot. The total number of plots was 27. The subplot to subplot distance was 1.5 m, and the main plot to main plot distance was 2m.

Crop cultivation and agronomic management

The land was first opened with a power tiller on October 16 2017. Later, the land was ploughed 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. In order 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 sulphate: 15kg ha^{-1} and Boric acid: 5kg ha^{-1}.Except for urea, whole triple super phosphate (TSP), muriate of potash (MP), zinc sulphate, and boric acid were applied at the time of final land preparation, while urea was applied as per experimental treatments.

The hybrid maize variety Kohinoor, marketed by Alpha Seed International, Bangladesh, was used in the experiment. Before sowing, collected seeds were treatedwith 4g of provax-200 wp/kg to prevent seeds from being attacked by seed and soil-borne diseases. On November 7, 2017, seeds were planted in rows 70 cm apart using a country plough to drill 3–4 cm deep furrows, with two seeds deposited in each furrow to grow one plant 25 cm apart. The seeds were sown continuously in the furrow at a rate of 30 kg ha^{-1}. Weeding was done thrice at 30, 45, and 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, 35, 55, and 85 DAS. Drainage was done when necessary using drainage channels. At maturity, the experimental crops were harvested plot-wise on March 18, 2018. Before harvesting, 2 m^2 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 plants (5 plants from each plot). The crops were sun-dried after harvest. Following that, grains were carefully washed and shelled, plot by plot. Prior to weighing them, the grains and stover were properly sun-dried. Grain yield was adjusted to 14% moisture content. Grain and stover yields were then converted into t ha^{-1}.

Determination of leaf chlorophyll content

A digital image analysis based on a 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 plants' Ch and N status (Ali *et al*., 2013). Images of the leaf samples were scanned using an HP Scanjet G2410 (Figure 1a). 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:

$$ChN_{RGB} = G - R/2 - B/2$$

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).

Results

During our study, growth, yield contributing characters, and yield of maize were evaluated. The plant height of maize plants for the application of basal urea was measured at 60, 90, and 120 DAS and is presented in **Table 1**. Plant height (cm) was not significantly influenced by basal urea rate at 60, 90, and 120 DAS. The maximum plant height was found at 128.68, 168.09, and 206.88 cm for 100% of the basal urea application rate (S_1) at 60, 90, and 120 DAS, respectively, whereas the lowest was 119.11, 162.08, and 196.93 cm at 60, 90, and 120 DAS, respectively for 50% of the basal urea application (S_3). The plant height of maize was not significantly influenced by the application of top dressing urea rate at 60, 90, and 120 DAS (Table 1). At 60 DAS, the highest (128.84 cm) plant height was observed with maximum (N_1) or 150% of top dressing urea amount and the lowest (119.96 cm) with a 50% or minimum top dressing urea amount (N_3). At 90 DAS, the maximum (169.82 cm) plant height was found in N_1, and the minimum (158.34 cm) was in N_3. At 120 DAS, plant height was also found to be highest (206.61 cm) with N_1 and lowest (195.19 cm) with N_3. Plant height was not statistically significant due to interactions between basal and topdressing urea applications (Table 1). At 60 DAS, the highest value (134.82cm) was found for the interaction of S_1 and N_1 and the lowest value (116.42cm) was for the interaction of S_3 and N_2. At 90 DAS, the interaction of S_1 and N_1 produced the

R: 119
G: 148
B: 30
HTML/HEX Code: #77941E
Mouse Location: {X=771,Y=221}

(b)

(a)

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

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

Basal urea rate	**Plant height (cm)**			**Leaf area (cm^2)**			**Chlorophyll content (ChN$_{RGB}$)**	
	60(DAS)	**90 (DAS)**	**120 (DAS)**	**60(DAS)**	**90 (DAS)**	**120 (DAS)**	**60 (DAS)**	**90 (DAS)**
S_1	128.68	168.09	206.88	972.53a	3465.70a	6058.49a	43.33	49.96
S_2	123.48	163.35	200.04	911.79ab	3255.87b	5846.12a	41.63	48.65
S_3	119.11	162.08	196.93	823.98b	3130.77b	5375.71b	39.62	47.09
LS	NS	NS	NS	0.01	0.05	0.05	NS	NS
Top dressing urea rate								
N_1	128.84	169.82	206.61	965.5	3469.42a	6001.49a	43.70a	51.33
N_2	122.47	165.35	202.04	896.64	3250.57b	5773.11ab	41.37ab	47.99
N_3	119.96	158.34	195.19	846.16	3132.36b	5505.72b	39.51b	46.39
LS	NS	NS	NS	NS	0.05	0.01	0.05	NS
Interaction effects								
S_1N_1	134.82	172.47	209.68	1059.74	3756.27	6222.03	45.65	52.57
S_1N_2	125.02	167.02	206.77	972.93	3424.65	6055.4	42.95	49.18
S_1N_3	126.22	164.78	204.2	884.91	3216.19	5898.05	41.38	48.13
S_2N_1	127.62	169.6	207.92	970.78	3398.62	6072.17	43.95	50.7
S_2N_2	125.98	163.98	197.33	898.37	3266.56	5862.72	41.5	48.53
S_2N_3	116.85	156.47	194.87	866.23	3102.42	5603.48	39.45	46.72
S_3N_1	124.1	167.4	202.23	865.99	3253.36	5710.26	41.5	50.72
S_3N_2	116.42	165.05	202.03	818.63	3060.48	5401.23	39.65	46.25
S_3N_3	116.82	153.78	186.52	787.33	3078.46	5015.63	37.7	44.32
LS	NS	NS	NS	NS	NS	NS	NS	NS
CV%	6.09	5.62	5.3	10.94	6.03	4.59	7.59	10.6

Mean followed by the same letters or without 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; S1= 100% of standard dose of nitrogen;S2= 75% of standard dose of nitrogen;S3= 50% of standard dose of nitrogen. N1= 150% of standard dose of nitrogen; N2= 100% of standard dose of nitrogen;N3= 50% of standard dose of nitrogen.

maximum plant height (172.47cm), whereas the interaction of S_3 and N_3 produced the lowest plant height (153.78cm). At 120 DAS, the interaction of S_1 and N_1 produced the maximum plant height (209.68 cm), whereas the interaction of S_3 and N_3 produced the lowest plant height (186.52 cm). Table 1 shows the total leaf area (cm^2) of maize plants for basal urea rate applications at 60, 90, and 120 DAS. The total leaf area varied dramatically depending on the basal urea rate applied at 60, 90, and 120 DAS. At 60 DAS, the leaf area of maize was found to be maximum (972.53 cm^2) for the maximum or 100 percent of basal urea application rate (S_1), which decreased drastically 6.25 and 15.27 % for S_2 and S_3, respectively. At 90 DAS, the leaf area of the maize plant was largest (3465.70 cm^2) for maximal basal urea treatment (S_1) and decreased dramatically 6.05 and 9.66 % for S_2 and S_3, respectively. Leaf area of maize plant at 120 DAS was also found highest (6058.49 cm^2) for maximum basal urea application (S_1), and it reduced slightly by 3.51% for S_2 and significantly by 11.27% for S_3. The total leaf area (cm^2) presented in Table 1 differed significantly due to the application of top dressing urea rate at 90 and 120 DAS. At 60 DAS, leaf area was found to be maximum (965.50 cm^2) with maximum (150%) top dressing urea rate (N_1) and minimum (846.16 cm^2)with minimum (50%) top dressing urea rate (N_3). 90 DAS, maximum (3469.42 cm^2) leaf area was found with $N_{1,}$ which was reduced significantly by 6.31% and 9.72% for N_2 and $N_{3,}$ respectively. At 120 DAS,the leaf area was also found maximum (6001.49 cm^2) with $N_{1,}$ which was reduced slightly by 3.81 % for N_2 and 8.26% for N_3.During our observations, we discovered that applying N to maize at later vegetative stages extended the development phase and produced considerably more assimilates by maize crop in response to the longer growth period; as a result, plant height and leaf area rose significantly. This might be attributed to maize's higher biomass production (Amanullah *et al*., 2008). The leaf area was not statistically significant due to the interaction between basal and top dressing urea application (**Table 1**). At 60 DAS, S_1 and N_1 produced the greatest leaf area (1059.47 cm^2), while the interaction of S_3 and N_3 produced the lowest value (787.33 cm^2). At 90 DAS, the interaction of S_1 and N_1 had the highest value of leaf area (3756.27cm2), while the interaction of S_3 and N_2 had the lowest value (3060.46cm2). At 120 DAS, the interaction of S_1 and N_1 produced the maximum leaf area (6222.03 cm^2), whereas the interaction of S_3 and N_3 produced the lowest value (5015.63 cm^2).

The chlorophyll content (ChN$_{RGB}$) of maize plants for the application of basal urea was measured on 60 and 90 DAS. The results are presented in Table 1. The chlorophyll content did not differ significantly due to the application of the basal urea rate at 60 and 90 DAS. At 60 DAS, chlorophyll content was highest (43.33) for the highest basal urea application rate (S_1) and lowest (39.62) for the lowest basal urea application rate (S_3). At 90 DAS, chlorophyll content was found to have a maximum of 49.96% for the highest basal urea application rate (S_1) and a minimum of 47.09% for the lowest basal urea application rate (S_3). Considering topdressing urea application rates, chlorophyll content was found to be significant at 60 and 90 DAS in Table 1. At 60 DAS, chlorophyll content was found to be maximum (43.70) with maximum top dressing urea amount (N_1), which was reduced slightly by 5.33% for N_2 but significantly by 9.59% for N_3. At 90 DAS, N_1 had the highest chlorophyll content (51.33) and N_3 had the lowest (46.39).

Chlorophyll content (ChN$_{RGB}$) was not statistically significant due to interactions between basal and topdressing urea applications (Table 1). At 60 DAS, the highest value (45.65) was found for the interaction of S_1 and N_1 and the lowest value (37.70) was recorded for the interaction of S_3 and N_3. At 90 DAS, the highest value

Table 2. Table 2: Effect of basal urea rate, top dressing urea rate and interaction effect on Total dry matter (TDM) gm-2 and CGR (gm-2day-1) of maize.

Basal urea rate	**Total dry matter (TDM) gm^{-2}**					**CGR (gm^{-2}day$^{-1)}$**		
	30 (DAS)	**60 (DAS)**	**90 (DAS)**	**120 (DAS)**	**140 (DAS)**	**30-60(DAS)**	**60-90(DAS)**	**90-120(DAS)**
S_1	2.67	45.75a	104.89	162.49a	211.72	9.90a	13.6	13.24
S_2	2.46	40.40ab	99.22	155.51b	210.43	8.72ab	13.52	12.94
S_3	2.29	36.91b	95.89	145.77c	209.15	7.96b	13.56	11.47
LS	NS	0.01	NS	0.05	NS	0.01	NS	NS
Top dressing urea rate								
N_1	2.66a	46.24a	104.33	165.03a	222.72a	10.02a	13.36	13.96a
N_2	2.43ab	41.15ab	100.22	154.66b	212.89ab	8.90ab	13.58	12.51ab
N_3	2.33b	35.67b	95.44	144.07c	195.69b	7.66b	13.74	11.18b
LS	0.01	0.01	NS	0.01	0.05	0.01	NS	0.05
Interaction effects								
S_1N_1	2.71	50.67	107.67	172.93	230.5	11.03	13.1	15.01
S_1N_2	2.69	45.78	106.33	162.56	210.44	9.9	13.92	12.93
S_1N_3	2.62	40.81	100.67	151.98	194.23	8.78	13.76	11.8
S_2N_1	2.67	47.74	104	163.41	220.22	10.36	12.93	13.66
S_2N_2	2.35	40.1	99.33	159.6	216	8.68	13.62	13.85
S_2N_3	2.37	33.37	94.33	143.51	195.06	7.13	14.01	11.31
S_3N_1	2.6	40.3	101.33	158.75	217.44	8.67	14.03	13.2
S_3N_2	2.25	37.58	95	141.82	212.22	8.12	13.2	10.76
S_3N_3	2.01	32.84	91.33	136.74	197.78	7.09	13.44	10.44
LS	NS	NS	NS	NS	NS	NS	NS	NS
CV%	9.2	1 3.44	13.17	3.5	9.79	13.75	8.33	13.05

Mean followed by the same letters or without 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; S1= 100% of standard dose of nitrogen;S2= 75% of standard dose of nitrogen;S3= 50% of standard dose of nitrogen. N1= 150% of standard dose of nitrogen; N2= 100% of standard dose of nitrogen;N3= 50% of standard dose of nitrogen.

(52.57) was found for the interaction of S_1 and N_1 and the lowest value (44.32) was observed for the interaction of S_3 and N_3. It was observed that total dry matter increased day by day with the advancement of the age of the plant. Total dry matter (gm) of maize for the application of basal urea was measured at 30, 60, 90, 120, and 140 DAS and is presented in **Table 2**. Total dry matter (TDM) differed significantly due to the application of basal urea at 60 and 120 DAS. At 30 DAS, TDM was found to have a maximum (2.67 gm) for the highest basal urea application rate (S_1) and a minimum (2.29 gm) for the lowest basal urea application rate (S3). At 60 DAS, S_1 had the highest total dry matter (TDM) (45.75 gm), slightly reduced to 11.69% for S_2 and 19.32% for S_3.At 90 DAS, total dry matter (TDM) of the maize plant was not significant for basal urea application rate, and the highest TDM (104.89 gm) was found in $S_{1,}$ and the lowest (95.89 gm) was in S_3. The maize plant's total dry matter (TDM) at 120 DAS was also found to be the highest (162.49 gm) for $S_{1,}$ and it was reduced significantly by 4.30 and 10.29% for S_2 and $S_{3,}$ respectively. At 140 DAS, the total dry matter did not differ significantly due to basal urea application and the highest value (211.72 gm) was found in S_1 and the lowest (209.15 gm) was in S_3. Total dry matter differed significantly due to the application of top dressing urea at 30, 60, 120, and 140 DAS (**Table 2**). At 30 DAS, total dry matter (TDM) was found to be highest (2.66 gm) with the maximum topdressing urea amount (N_1), which was reduced slightly (8.65%) in N_2 but significantly by12.41% in N_3.At 60 DAS, total dry matter (TDM) was found at a maximum (46.24 gm) with N_1, which reduced slightly by 11.11% for N_2 and significantly by 22.86% for N_3. At 90 DAS, the maize plant's total dry matter (TDM) was not significant for topdressing urea application rate, but the highest TDM (104.33 gm) was found in the highest topdressing urea application rate. At 120 DAS, N_1 had the highest TDM (165.03 gm), which was significantly reduced by 6.28% and 12.70% for N_2 and N_3, respectively. Finally, at 140 DAS, maximum (222.72 gm) TDM was found with N_1, which was reduced slightly by 4.45% for N_2 and significantly by 12.14% for N_3. Total dry matter (TDM) was not statistically significant due to interactions between basal and topdressing urea applications (**Table 2**). At 30 DAS, the interaction between S_1 and N_1 had the highest TDM (2.71 gm), and the interaction between S_3 and N_3 had the lowest (2.01 gm). At 60 DAS, the interaction of S_1 and N_1 had the highest value (50.67 gm), and the interaction of S_3 and N_3 had the lowest value (32.84 gm). At 90 DAS, the interaction of S_1 and N_1 gave the highest value (107.67 gm), and the interaction of S_3 and N_3 gave the lowest value (91.33 gm). At 120 DAS, the interaction between S_1 and N_1 had the highest value (172.93gm), while the interaction between S_3 and N_3 had the lowest value (136.74gm). At 140 DAS, the interaction of S_1 and N_1 had the highest value (230.5 gm), and the interaction of S_1 and N_3 had the lowest value (194.22 gm). The crop growth rate (CGR) of maize plants for basal and top dressing urea was measured on 30-60, 60-90 and 90-120 DAS are presented in **Table 2**. The CGR showed significant effect due to the basal application of urea at 30-60 DAS but showed a non-significant effect due to the basal application of urea at 60-90 DAS and 90-120 DAS. Crop growth rate (CGR) was found9.90, 13.60 and 13.24 gm^{-2}day^{-1} for basal application of urea at 30-60, 60-90, and 90-120 DAS, respectively.At 30-60 DAS, crop growth rate (CGR) was found maximum (9.90) for highest basal urea application rate or S_1, which reduced slightly 11.92 % for S_2 and significantly 19.60 % for S_3. At

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

Basal urea rate	Cob length (cm)	No. of grains cob^{-1}	1000 grain Weight (gm)	Grain Yield (t ha^{-1})	Stover Yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)
S_1	17.97	388.31	266.18	9.61	14.23a	23.84a	40.31
S_2	17.07	376.13	261.72	9.01	13.47b	22.48b	40.11
S_3	16.72	360.58	256.05	8.74	12.44c	21.18c	41.36
LS	NS	NS	NS	NS	0.01	0.01	NS
Top dressing urea rate							
N_1	17.94a	390.52	267.98a	9.61a	14.40a	24.01a	40.02
N_2	17.13b	370.33	260.51ab	9.02b	13.12b	22.14b	40.79
N_3	16.68b	364.18	255.46b	8.72b	12.61b	21.33b	40.97
LS	0.05	NS	0.05	0.05	0.01	0.01	NS
Interaction effects							
S_1N_1	19.03	407.78	276.3	10.26	15.06	25.32	40.53
S_1N_2	17.9	384.39	263.98	9.49	14	23.49	40.44
S_1N_3	16.98	372.75	258.27	9.07	13.63	22.7	39.95
S_2N_1	17.62	389.23	267.8	9.48	14.5	23.98	39.54
S_2N_2	17.07	377.11	260.58	8.9	13.28	22.18	40.11
S_2N_3	16.51	362.06	256.77	8.65	12.61	21.26	40.68
S_3N_1	17.17	374.56	259.85	9.09	13.64	22.74	40
S_3N_2	16.43	349.47	256.97	8.67	12.08	20.76	41.81
S_3N_3	16.56	357.72	251.33	8.45	11.58	20.03	42.29
LS	NS	NS	NS	NS	NS	NS	NS
CV%	4.47	5.92	2.99	5.76	3.08	3.29	3.35

Mean followed by the same letters or without 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; S1= 100% of standard dose of nitrogen;S2= 75% of standard dose of nitrogen;S3= 50% of standard dose of nitrogen. N1= 150% of standard dose of nitrogen; N2= 100% of standard dose of nitrogen;N3= 50% of standard dose of nitrogen.

60-90 and 90-120 DAS, crop growth rate (CGR) was not found significant for basal urea application. The highest CGR (13.60) was found in highest basal urea application rate (S_1), and the lowest CGR (13.52) was found from lowest basal urea application rate (S_2) at 60-90 DAS. At 90-120 DAS, highest (13.24) CGR was observed with S_1 and the lowest CGR (11.47) was found from the lowest basal urea application rate (S_3).

Considering top dressing urea rates, crop growth rate of maize was foundto be significant at 30-60 DAS and 90-120 DAS, and non-significant at 60-90 DAS (**Table 2**). At 30-60 DAS, crop growth rate (CGR) was found maximum (10.02) with maximum top dressing urea amount (N_1), which was reduced slightly by 11.18 % for N_2 and significantly 23.55 % for N_3. Crop growth rate (CGR) did not vary significantly due to top dressing urea at 60-90 DAS. The highest CGR (13.74) was found in the lowest top dressing urea amount (N_3), and the lowest (13.36) was from the highest top dressing urea amount (N_1). At 90-120 DAS, crop growth rate (CGR) was also found maximum (13.95) with maximum top dressing urea amount (N_1), which reduced slightly to 10.39 % for N_2 but significantly to 19.91 % for N_3. Based on the above results, it can be said that when there isn't enough nitrogen in the soil, crop growth slows down, which causes reproductive structures to weaken. This leads to a lower maize grain yield (and its parts), harvest index, and leaf area duration (O'Neill et al., 2004). No significant effect was found due to the interaction between basal urea application and topdressing urea application on crop growth rate (CGR) is presented in Table 2. During the period of 30-60 DAS, the interaction of S_1 and N_1 had the highest crop growth rate (11.03 gm^{-2} day^{-1}) and the interaction of S_3 and N_3 had the lowest (7.09). At 60–90 DAS, the interaction between S_3 and N_1 had the highest value (14.03), and the interaction between S_2 and N_1 had the lowest value (12.93). At 90-120 DAS, the interaction between S_1 and N_1 had the highest value (15.01), and the interaction between S_3 and N_3 had the lowest value (10.44). 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 (17.97cm) for the highest basal urea application rate (S_1) and minimum (16.72 cm) for lowest basal urea application rate (S_3). Cob length differed significantly due to application of top dressing urea rate which is presented in Table 3. The maximum length of maize was also found to be maximum (17.94 cm) with maximum top dressing urea amount (N_1), which was significantly reduced to 4.52% for N_2 and 7.02% for N_3. The interaction between basal and top dressing urea application did not differ significantly (**Table 3**). The highest cob length (19.03 cm) was observed for the interaction of S_1 and N_1 and the lowest value (16.43 cm) was recorded for the interaction of S_3 and N_2.

The number of grains per cob of maize are presented in Table 3 was not differed significantly for basal urea rates. The number of grains per cob of maize was found maximum (388.31) for highest basal urea application rate or S_1, minimum (360.58) for lowest basal urea application rate (S_3). The number of grains per cob of maize did not differ significantly due to application of top dressing urea rate presented in Table 3.The number of grains per cob was found to be highest (390.52) with the highest amount of urea (N_1) and lowest (364.18) with the lowest amount of urea on top (N_3).

Basal and topdressing urea applications did not significantly affect each other (**Table 3**). Combination of S_1 and N_1 produced the most grains per cob (407.78), and the interaction between S_3 and N_2 produced the fewest (349.47).

1000 grain weight (gm) of maize are presented in Table 3 and was not influenced significantly by basal urea rates. 1000 grain weight (gm) of maize was found maximum (266.18gm) for the highest basal urea application rate (S_1) and minimum (256.05 gm) for lowest basal urea application rate (S_3). Table 3 shows that the application of top dressing urea rate significantly affected the weight of 1000 grains of maize. 1000 grain weight (gm) of maize was also found to be highest (267.98 gm) with the highest amount of top dressing urea (N_1), which dropped by 2.79 % for N_2 but by 4.67 % for N_3. The interaction between basal and topdressing urea application did not differ significantly (Table 3). The highest 1000 grain weight (gm) (276.30 gm) was observed for the interaction of S_1 and N_1 and the lowest (251.33 gm) was for the interaction of S_3 and N_3.

Grain yield of maize presented in Table 3, figure 2 was not influenced significantly by basal urea rates. Grain yield was found to be highest (9.61 t ha^{-1}) for the highest basal urea application rate (S_1)and lowest (8.74 t ha^{-1}) for the lowest basal urea application rate (S_3).Grain yield of maize differed significantly due to application of top dressing urea rate presented in Table 3, figure 3. Grain yield was also found to maximum with maximum (9.61 t ha^{-1}) top dressing urea amount (N_1), which reduced significantly by 6.14 % for N_2 and 9.26 % for N_3. A number of previous research (Modhej *et al*., 2014) claim that nitrogen (N) fertilizer use has played a significant role in the increase of crop yield and yield reduction in corn due to nitrogen deficiency more than other elements deficiency.The interaction between basal and topdressing urea application did not differ significantly (**Table 3**). The interaction of S_1 and N_1 gave the highest grain yield of 10.26 t ha^{-1}, and the interaction of S_3 and N_3 gave the lowest grain yield of 8.45 t ha^{-1}. **Table 3 and Figure 2** show that the stover yield of maize greatly affected the basal urea rates. Stover yield was highest (14.23 t ha^{-1}) at the highest basal urea application rate (S_1), but it dropped by a lot at S_2 (5.34%) and S_3 (12.58%).

Stover yield of maize differed significantly due to application of top dressing urea rate presented in Table 3, Figure 3. Stover yieldwas also found maximum with maximum (14.40 t ha^{-1}) top dressing urea amount (N_1) which reduced significantly 8.89% for N_2 and 12.43 % for N_3.The interaction between basal and topdressing urea application did not differ significantly (Table 3). The highest stover yield of 15.06 t ha^{-1} was observed for the interaction of S_1 and N_1 and the lowest value 11.58 t ha^{-1} was recorded for the interaction of S_3 and N_3.

Biological yield differed significantly for basal urea rates as presented in **table 3, Figure 2.** Stover yield was foundto maximum (23.84 t ha^{-1}) for the highest basal urea application rate or S_1, which reduced significantly by 5.70 % for S_2 and 11.16 % for S_3. The biological yield of maize differed significantly due to the application of top dressing urea rate, which is presented in Table 3, Figure 3. Biological yield also found maximum (24.01 t ha^{-1}) with maximum topdressing urea amount (N_1), which reduced significantly by 7.79 % for N_2 and 11.16 % for N_3. According to the foregoing findings, irrigated maize output grew with increasing N treatments until maize production plateaued and dropped (Shapiro and Wortman, 2006). Interaction between basal and topdressing urea application was not differed significantly (Table 3). The interaction of S_1 and N_1 produced the highest biological production (25.32 t ha^{-1}), whereas the S_3 and N_3 produced the lowest biological yield (20.03 t ha^{-1}).The harvest index was not differed significantly due to basal urea application rates (Table 3). The highest harvest index (41.36%) was found for S_3 or 50% of recommended basal urea application, and thelowest harvest index (40.11 %) was found for S_2 or 75 % of recommended urea application. Harvest index (HI) of maize did not differ significantly due to application of top dressing urea rate presented in (Table 3)**.** Considering urea topdressing rates, highest harvest index (40.97%) was for N_3 and lowest harvest index (40.02%) was found for N_1.The interaction between basal and topdressing urea application did not differ significantly **(Table 3**). The highest harvest index (42.29) was observed for the interaction of S_3 and N_3 and the lowest value (39.54) was recorded for the interaction of S_2 and N_1.

The above experiment found that both basal and topdressing urea application play a critical role in growth and yield performance in maize. Basal urea is important for initial growth parameters thus, it produces maximum stover yield, whereas topdressing urea is responsible for maize growth in the reproductive stage. Nitrogen is the most critical nutrient element in crop production. Therefore, it is vital for maintaining and improving crop growth and yield (Gonias *et al*., 2011).During our experiment, it was also found that measurement leaf chlorophyll content based on RGB color code model would be a good measurement for crop nitrogen status and this value can be used to apply urea or other nitrogen fertilizer as required by the crop.

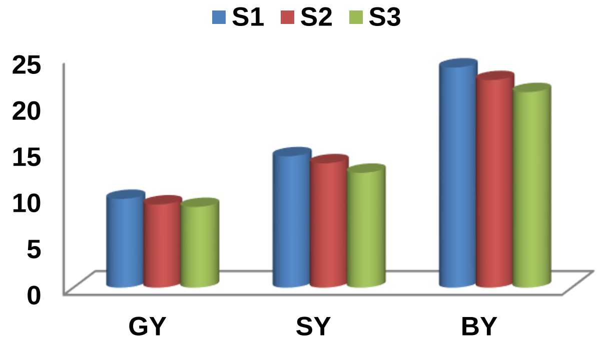

Figure 2. Effect of basal urea rate on yield components and yield of maize.

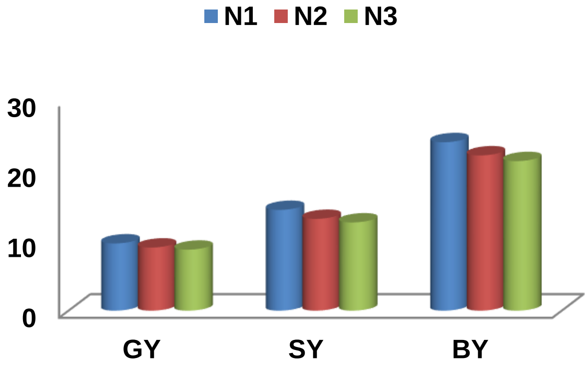

Figure 3. Effect of top dressing urea rate on yield components and yield of maize.

Conclusions

The experiment was carried out at the Agronomy Field Laboratory, University of Rajshahi. It examined the effect of basal urea application rate (S1= 100% of standard dose of nitrogen) on the growth, physiological responses and yield of maize (Zea mays L.). The maize crop was harvested on March 18, 2018 at full maturity. Five plants were randomly selected and uprooted from each unit plot before harvest. The collected data were analyzed using analysis of variance (ANOVA) technique. Most of the time highest result was found in maximum urea application rate. Most of the growth characters, such as plant height (cm), leaf area (cm^2) total dry matter (gm) and crop growth rate ($gm^{-2}day^{-1}$) was found to have the highest numerical data in maximum topdressing urea application rate (N_1). Based on our findings, it can be stated that both basal and top dressing urea application are important for growth and yield performance in corn. Basal urea is important for the initial growth of corn, and it produces maximum stover yield, whereas top dressing urea is responsible for maize growth in reproductive stage. It can also be suggested that, the greenness of maize leaf can be measured using algorithm based on the RGB, and this value could be a good indicator to determine urea topdressing amount.

Acknowledgement

This research is funded by special allocation (2018-19 & 2019-20) from the Ministry of Science and Technology, Peoples Republic of Bangladesh.

References

Ali, M. M., Al-Ani, A., Eamus, D. and Tan, D. K. Y. 2013. An Algorithm Based on the RGB Colour Model to Estimate Plant Chlorophyll and Nitrogen Contents. International Conference on Sustainable Environment and Agriculture (IPCBEE). 57: 52-56.

Amanullah, H. Rahman and Z. Shah. 2008. Effects of plant density and N on growth dynamics and light interception in maize. Archives of Agronomy and Soil Science, 54: 401-411.

BARI (Bangladesh Agricultural Research Institute). Annual report for 2011-12. Bangladesh Rice Research Institute - Gazipur, Bangladesh, https://www.barilibrary.org/index.php?p=show_detail&id=5771&keywords=

Chandra shekara, C.P. 2009, Resource management in sugarcane (*Saccharum officinarum L.*) through drip irrigation, fertigation, planting pattern, and LCC based N application and area - production estimation through remote sensing. Ph.D..(Agri.)Thesis, Uni. Agric. Sci., Dharwad (India).

Chowdhury, M.K And M.A. Islam. 1993. Production and uses of maize (in Banglali) Pub. by on Farm Des. Div. Bangladesh agril. Res. Inst. Joydebpur gazipur, Bangladesh. P.P 1-189

Gonias, E. D., D. M. Oosterhuis and A. C. Bibi. 2011. Light interception and radiation use efficiency of okra and normal leaf cotton isolines. Environmental and Experimental Botany 72: 217–222.

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedures for Agricultural Research. (2 edn.) John Wiley and Sons. Newyork. Chikester, Brisbane, Toronto. Singapore. p.680.

Gulati A and Dixon, J .2008. Maize in Asia: Changing Markets and Incentives, Academic Foundation, New Delhi.

https://europa.eu/newsroom/events/agri-innovation-summit-ais-2017_en

Karim, Z., Hussain, S. G. and Ahmed, M. 1990. Salinity problems and crop intensification in the coastal regions of Bangladesh, BARC, Soil publication No. 33:63

Kumar, R., Srinivas, K., Miah, M. M., Shah, H., Dahlan, H. A., & Qiu, H. (2014). Assessment of the maize situation, outlook and opportunities in Asia.

Modhej, A., Kaihani, A., & Lack, S. (2014). Effect of nitrogen fertilizer on grain yield and nitrogen use efficiency in corn (Zea mays L.) hybrids under irrigated conditions. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, 84(3), 531-536.

Moniruzzaman, M. S. Rahman M. S., Karim, M. K and Alam, Q. M. 2009.Economic analysis of maize production in Bangladesh. *J. Agril. Res.*, 34(1):15-24.

Moriri, S., Owoeye, L.G. and Mariga, I. K. 2010. Influence of component crop densities and planting patterns on maize production in dryland maize/cowpea intercropping systems. *Afr. J. Agri. Res*., 5 (11); 1200 -1207.

Nelson, R.L. 2005. Tassel emergence and pollen shed. Corny news network.

O'Neill, P.M., Shanahan, J.F., Schepers, J.S., Caldwell, B. 2004. Agronomic responses of corn hybrids from different eras to deficit and adequate levels of water and nitrogen.Agron. J. 96: 1660-1667.

Shapiro, C.A.; Wortmann, C.S. Corn response to nitrogen rate, row spacing and plant density in Eastern Nebraska. *Agron. J.* 2006, 98, 529–535.

To cite this article: Razzak, A., Biswas, B., Khan, T. A., Yasmin, N., Alam, A. M.S. and Islam, M. R. (2022). Precision Nitrogen Management in Corn (*Zea mays* L.) Using Algorithm Based on the RGB Color Codes by Digital Imaging. *International Journal for Asian Contemporary Research,* 2 (2): 50-57.