GROWTH AND YIELD OF WHITE MAIZE AS INFLUENCED BY EARTHING UP PRACTICES AND APPLICATION METHODS OF NITROGEN FERTILIZER

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CERTIFICATE

*This is to certify that the thesis entitled, "**GROWTH AND YIELD OF WHITE MAIZE AS INFLUENCED BY EARTHING UP PRACTICES AND APPLICATION METHODS OF NITROGEN FERTILIZER**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (MS) in AGRONOMY**, embodies the result of a piece of bona-fide research work carried out by **PUSPO CHANDRA DEY**, Registration no. **15-06614** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Date:

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Dedicated to

My

Beloved Parents

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ABSTRACT

A field experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka during the period from October-2021 to February-2022 in Rabi season, to study the growth and yield of white maize as influenced by earthing up practices and application methods of nitrogen fertilizer. The experiment consisted of two factors, and followed split plot design with three replications. Factor A: Earthing up practices (2) *viz*: E_0= No earthing up E_1= Earthing up at 45 DAS and Factor B: Application method of nitrogen fertilizer (3) *viz*: N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS. The analysis of various parameter data revealed significant differences in maize growth and yield, as a result of earthing up practices and different application method of nitrogen fertilizer and their combination treatment. In the case of different earthing up practices, the lowest grain yield (6.86 t ha^{-1}) was observed in E_0 treatment. Whereas applying earthing up practices at 45 DAS (E_1) gave the highest cob length (21.50 cm), cob circumference (18.19 cm), rows cob^{-1} (14.04), grains row^{-1} (27.88), total grains cob^{-1} (392.00), 1000 grain weight (298.33 g) and grain yield (7.60 t ha^{-1}). Among different application methods of nitrogen fertilizer, the highest cob length (21.99 cm), cob circumference (18.66 cm), rows cob^{-1} (15.47), grains row^{-1} (28.27), total grains cob^{-1} (437.48), 1000-grains (311.67 g) and grain yield (8.10 t ha^{-1}) were observed in N_3 treatment. In the case of combination, E_1N_3 treatment combination gave the highest cob length (22.66 cm), cob circumference (19.16 cm), rows cob^{-1} (15.67), grains row^{-1} (28.66), total grains cob^{-1} (449.10), 1000 grains (331.67 g) and grain yield (8.50 t ha^{-1}) of white maize. Therefore, it was suggested that cultivating of white maize through applying earthing up practice at 45 DAS along with three splits application of nitrogen fertilizer @ 33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS would help to influenced plant growth and increase its ability to enhanced better yield production of white maize compared to other treatment combinations.

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LIST OF ABBREVIATIONS

Full word	Abbreviations
Agriculture	Agr.
Agro-Ecological Zone	AEZ
Bangladesh Bureau of Statistics	BBS
Biology	Biol.
Biotechnology	Biotechnol.
Botany	Bot.
Cultivar	Cv.
Dry weight	DW
Editors	Eds.
Emulsifiable concentrate	EC
Entomology	Entomol.
Environments	Environ.
Food and Agriculture Organization	FAO
Fresh weight	FW
International	Intl.
Journal	J.
Least Significant Difference	LSD
Liter	L
Triple super phosphate	TSP
Science	Sci.
Soil Resource Development Institute	SRDI
Technology	Technol.
Serial	Sl.

CHAPTER I

INTRODUCTION

Maize (*Zea mays*) is the most important cereal crop in Bangladesh after rice and wheat. It has potential nutritional values i.e., 100 grams of mature maize seeds contain 9.42 g of protein, 74.26 g carbohydrates, 0.64 g sugar, 7.3 g dietary fiber, 365 kcal energy (Islam and Hoshain, 2022). At present, the annual demand for maize in Bangladesh is around two million tons, but production is 4,700 thousand tonnes (BBS, 2021) which is a big gap between demand and production. To fulfill the demand, huge amount of money drains to import maize seeds and products. The consumption of maize in Bangladesh both as human food, livestock and poultry feed overall in all the segments will be increased in the future. In addition, maize has a potential prospect in Bangladesh and annual average weather had a positive effect on maize production in Bangladesh.

Maize has a wide genetic variability and able to grow successfully in any environment in Bangladesh. It generally grows both in winter and summer time in Bangladesh and shows potential yield. Recently, the yield of maize has experienced explosive growth in Bangladesh. Maize has now positioned itself as the first among the cereals in terms of yield (6.15 t ha^{-1}) as compared to boro rice (3.90 t ha^{-1}) and wheat (2.60 t ha^{-1}) (BBS, 2020).

There are two kinds of maize in respect of grain colour; yellow and white. Worldwide, the yellow maize is mainly used as fodder while the white ones are consumed as human food (Revilla *et al*., 2022). The currently grown maize in this country is yellow type, which is mainly adapted importing genetic materials from CIMMYT. Again, although there are some indigenous local maize in the south east hills those have also not improved for having higher yields (Ullah *et al.*, 2016). Maize currently grown in Bangladesh is of yellow type and is used in the feed industry. Hybrid maize cultivation area has increased at the rate of about 20-25% per year since nineties as the yield potential of hybrid maize is greater than those of local races (Shompa *et al*., 2020). Now-a-days, there are many government and non government organizations are working for increasing maize production in Bangladesh.

Bangladesh Agricultural Research Institute (BARI) has developed seven open pollinated and 11 hybrid varieties whose yield potentials are 5.50–7.00 t ha^{-1} and 7.40–12.00 t ha^{-1}, respectively, which are well above the world average of 3.19 t ha^{-1} (Nasim *et al*., 2012). Different varieties respond differently to input supply, cultivation practices and prevailing environment etc, during the growing season (Bithy and Ahamed, 2018). The low productivity of maize is attributed to many factors like decline of soil fertility, poor agronomic practices (such as proper management of planting configuration, irrigation interval, fertilizer managements, weeding, thinning, earthing up, clipping etc), and limited use of input, insufficient technology generation, poor seed quality, disease, insect, pest and weeds (Ullah *et al.*, 2017).

Among various interculture practices involved in the cultivation of maize earthing up holds a significant position. It is a practice of putting soil around crown, collar or adventitious roots of a plant, so that these roots can grow and develop properly. It helps in extensive development of plant roots, destroying the weeds, prevents lodging and assures efficient management of irrigation water. By preventing the lodging of the plant, earthing up ensures better stand ability in the crop. Earthing up provides fine tilth with better aeration in root zone which ensures favourable conditions for root development. Better aeration protects the plants from water logging which is very harmful in case of maize crop. Moreover, it also provides anchorage to the lower whorls of adventitious roots above the soil level which then function as absorbing roots and supports the plant by absorbing nutrients and water (Bhatnagar and Kumar, 2017).

Another issue that counteracts the successful cultivation of maize is management of nitrogenous fertilizers. Maize is an exhaustive crop and requires high quantities of nitrogen during the period of efficient utilization, particularly at 30 days after sowing and pretasselling (40 days after sowing) stages for higher productivity. Nitrogen is indispensable for increasing crop production as a constituent of protoplasm and chlorophyll and is associated with the activity of every living cell. However, farmers often misinterpret the relationship between grain yield and nitrogen fertilization, and thus overestimate the yield benefits. This results in excessive nitrogen fertilizer application in agricultural production (Gao *et al*., 2020). In fact, excessive nitrogen application does not significantly improve the grain yield once the levels have exceeded the ability of plants to uptake nitrate

(Wang *et al.*, 2020). Therefore, it was necessary to give optimum dose of nitrogen for improving quality of maize (Li *et al.*, 2021).

Efficient use of nitrogen by maize, permits use of appropriate source in an adequate amount, at proper timing and suitable application rates (Rizwan *et al*., 2003). The utilization efficiency of added nitrogen fertilizer is very low, as applied nitrogen is subjected to various kinds of losses like leaching, volatilization and de-nitrification. The efficiency of applied N fertilizer not only depends on right quantity but also on right time, method of N application, crops and different genotypes of the same crops. Timing of N application is also deliberated as the best managing strategy and is very crucial for maize production (Walsh, 2006).

Split application of nitrogen (N) is a management strategy for corn that has been practiced on a limited basis for years. Coarse textured, sandy soils have often received split applications to improve N uptake and efficiency and reduce leaching loss. Some N (less than half) is generally applied prior to or at planting and the rest (usually more than half) is side dressed prior to tasselling. The side dress applications may consist of either a single application or multiple applications, which are usually associated with irrigation. Because a greater portion of the N is applied closer to the time of maximum N uptake, split application strategies are often considered as being more efficient and environmentally sound. For these reasons and others, split application of N is becoming more popular on medium and fine textured soils. Additionally, as the price of N increases, growers will give greater consideration to N management practices that are more efficient and save money. Hassan *et al.* (2010) reported that application of nitrogen in three splits at planting, V_4 and V_6 stages significantly increased number of leaves plant^{-1}, plant height, leaf area index, leaf area duration, crop growth rate and total dry matter. Mariga *et al*. (2000) reported that biomass yield in maize considerably increased when nitrogen was applied up to tassel initiation stage. Scharf *et al*. (2002) observed significant increase in maize yield when nitrogen was applied in splits. In order to get highest and appropriate vegetative growth and yield, increasing the nitrogen use efficiency by crop could be achieved through best management practices of nitrogen (Rehmati, 2009).

In Bangladesh few studies have been conducted with earthing up practices and application methods of nitrogen fertilizer on white maize. Research work on the combined effect of earthing up practices and application methods of nitrogen fertilizer is limited. Considering the above facts the present study was undertaken to find out the growth and yield of white maize as influenced by earthing up practices and application methods of nitrogen fertilizer with the following objectives:

i. To explore the effects of earthing up practices on plant growth and yield characteristics of maize.
ii. To investigate the effect of application methods of nitrogen fertilizer on growth and yield of maize.
iii. To determine the ideal combination of earthing up practices and application method of nitrogen fertilizer for improving the growth and productivity of white maize.

CHAPTER II

REVIEW OF LITERATURE

The relevant literature pertaining to find out the growth and yield of white maize as influenced by earthing up practices and application methods of nitrogen fertilizer. Since the available literature is scanty on this crop, the literature on other related crops was collected and reviewed under the following headings-

2.1 Effect of earthing up practices

Nath *et al.* (2022) conducted a field experiment during the kharif season, 2017 and 2019, at Pantnagar, India with three levels of tillage practises (T_1- Conventional tillage, T_2 - Minimum tillage, and T_3- Deep tillage) and five levels of earthing up practises (E_1 - Earthing by Pant fertilizer band placement- cum- earthing machine, E_2 - Earthing by Earther, E_3 - Manual Earthing, E_4 - Earthing by cultivator, E_5 - No earthing) with three replications in a split plot design. Experimental result revealed that the earthing by pant fertilizer band placement cum earthing machine treatment yielded 9.25 percent more grain than earthing by earther, 20.65 percent more than manual earthing, 22 percent more than earthing by cultivator, and 36 percent more than no earthing treatment.

Bhatnagar and Kumar (2017) reported from Pantnagar that the earthing up operation in maize has produced a remarkable effect on plant height of maize as compared to no earthing treatment. Further, they stated that mechanized earthing was found to be at par with other methods of earthing up i.e. manual and by use of cultivator.

Islam *et al.* (2017) from Regional Agricultural Research Station, Bangladesh reported that in maize crop the treatment M_2 (earthing up at 25 days after emergence) recorded higher values of Leaf Area Index, total dry matter accumulation, Crop Growth Rate (CGR) and Light Energy Interception (LEI) as compared to other treatments *viz*. M_1 (soil mulching at 25 days after emergence), M_3 (straw mulching at 25 days after emergence) and M_4 (control: without earthing up and mulching).

Painyuli *et al.* (2013) conducted a field experiment at Pantnagar, Uttarakhand in spring season of 2009 and 2010 on planting techniques and irrigation scheduling in sweet corn

(*Zea mays* Saccharata). The experimental results after pooled analysis suggested that increase in green cobs and fodder yields was 5.1 and 15.2% and 5.0 and 12.6% on ridge planted crop over flat + earthing up and flat planted sweet corn, respectively. Further, they concluded that spring planted sweet corn can be best grown under ridge planting with irrigation scheduled at 75 mm CPE for optimum yield.

Khan *et al.* (2012) studied the response of maize crop towards earthing up practices and they found that maize crop grown on ridges and beds recorded highest plant height as compared to maize grown on flat beds. Maize plants grown on ridge planting recorded more length of primary roots as compared to flat planting methods but it was at par with bed planting at 75 and 90 DAS. Ridge planting also recorded higher LAI and CGR which further resulted in higher values of 1000 grain weight and number of grains per cob.

Sultana *et al.* (2012) reported from their experiment on maize crop that earthing up holds potential scope in increasing maize yield by its prominent role in reducing weed population. Earthing up also increased the efficiency of applied herbicides. Out of various treatments, T_4 (two spading along with hand weeding at 10 and 20 DAE + Earthing up at 30 DAE) and T_5(application of pre emergence herbicide magnum gold (mencozeb) @ 2 5 ml L water + Earthing up at 30 DAE) recorded highest values of maize grain yield (7.47 t ha^{-1} and 7.24 t ha^{-1}, respectively).

Chattha (2010) reported from Sugarcane Research Institute, Faisalabad, Pakistan that maximum number of tillers in sugarcane were reported with no earthing (14.34 tillers m^{-2}) followed by earthing at 120 DAP (14.28 tillers m^{-2}).

Ahmad and Chudhry (2008) conducted a study to assess the effect of earthing up on maize. The experimental findings revealed that flat sowing with earthing up resulted in maximum grain yield (5236 kg ha^{-1}), but it was found to be at par with ridge sowing (4343 kg ha^{-1}). Flat sowing with earthing up also recorded lowest values of lodging percentage i.e. 14.36% and 7.27% in both the years.

Aslam *et al.* (2008) reported from their experiment that earthing up is sugarcane was responsible for reduced lodging and it increased the content of commercial cane sugar in the crop. Earthing up with spade increased the cane yield by 19.20%, whereas earthing up with ridger increased the yield by 18.00%.

Thakur *et al.* (2003) revealed that maize plant recorded significantly higher grain and straw yield on vertisols of Madhya Pradesh, when it was provided with earthing up at 25 days after sowing as compared to the treatments in which earthing up was not done and plants were sown as flat planting.

A field experiment was conducted by Usman and Amanullah (2002) to find out the best time for earthing up operation in sunflower crop in order to obtain maximum yield. The authors selected different ecological zones to conduct the experiment and the results indicated that in sunflower crop earthing up should be done before bud formation to obtain maximum yield. Delayed earthing up and flat sowing resulted in considerable loss in yield. Therefore, the researchers concluded that earthing up operation done before bud formation was helpful in achieving higher yield in sunflower.

Pandey *et al.* (2001) reported from Almora, Uttarakhand that highest values of yield attributes and highest grain yield (4080 kg ha^{-1}) was obtained in maize from the treatment Allachlor + Earthing up. Further, they reported that in terms of weed control earthing up treatment was most effective followed by hand weeding and paraquat application.

Ahmad *et al.* (2000) conducted a study to assess the effect of different inter tillage practices on spring maize cultivar “Golden”. The experimental results revealed that maximum plant height (195.66 cm) was observed in the treatment involving; inter tillage twice with spade+ Earthing up and it was significantly superior to no tillage + no earthing up treatment. The authors further stated that it could be because of the better growing conditions that resulted by inter tillage and earthing up.

2.2 Effect of application methods of nitrogen fertilizer

Gharge *et al.* (2020) conducted a field experiment was designed to study the effect of split nitrogen application on growth parameters of maize on research field of agricultural development trust, Baramati for two consecutive years during rainy season in 2017and 2018. An experiment was laid out in randomized complete block design with four replications. Four splits application of recommended dose of N were applied as 50% N at basal and 50% N at knee high stage (T_1), 50% N at basal, 25% N 30 days after sowing and 25% N at tasseling stage (T_2), 50% N at basal and remaining nitrogen as per Leaf Colour Chart (T_3) and 30% N at basal, 30% N at 30 days after sowing and 30% N at tasseling stage (T_4). Results showed that all studied parameters were significantly affected by application time of nitrogen. Experimental results exhibited that application of 50% N at basal and remaining nitrogen as per Leaf Colour Chart (LCC) has produced maximum plant height, number of leaves per plant and cob length. Results of these studies revealed that, application of N fertilizers based on leaf colour chart, would be more economical to minimize N losses from the soil and efficient use of N at critical growth and development stages of maize.

Ogunboye *et al*. (2020) carried out an experiment to study the effects of Split Application of Urea Fertilizer on Soil Chemical Properties, Maize Performance and Profitability in Southwest Nigeria and found that application of N fertilizer increased the growth of maize at both sites (except the number of leaves and leaf area for site II) compared with the control. The values of maize growth parameters increased in the order: control < 120 kg N ha^{-1} applied once < 90+30 < 60+30+30. Yield parameters such as weight of cob/plant increased significantly with the application of N fertilizer compared with the control. The yield parameters increased in the order: control < 120 kg N ha^{-1} applied once < 90+30 < 60+30+30.

Umesh *et al.* (2020) reported that application of 80-110 kg N ha^{-1} using threshold LCC < 4.5 inclusive of 62.5 kg N ha^{-1} basal resulted in higher grain yield of maize which was at par with the application of 150 kg N ha^{-1} applied in 3 equal split doses.

Naik *et al.* (2019) calibrated LCC for nitrogen management under varied plant density to establish threshold leaf color greenness as a guide for right quantity of fertilizer N to be top dressed in maize. The results disclosed that the initial & final plant population, plant height, dry matter accumulation and finally yield of maize increased significantly with increase in plant density, with application of fertilizer nitrogen at higher dose i.e., 40 kg ha^{-1} by using higher LCC threshold value (LCC-5) at different splits, whereas, by using higher LCC threshold value (LCC-5) significantly increased leaf area and SPAD values.

Subedi *et al*. (2018) reported that pure LCC based N application had significantly higher agronomic efficiency (16 kg grain kg^{-1} N) and recovery efficiency (52 %) and partial factor productivity (43.56 kg grain kg^{-1} N) as compared to 120 kg ha^{-1} N in three split applications, 30 kg ha^{-1} N as basal followed by LCC based N application and 30 kg ha^{-1} N at 15 DAS followed by LCC based N application.

Swamy *et al.* (2016) studied nitrogen management in sweet corn (*Zea mays* saccharata L.) using simple hand-held decision tools. It was concluded by the study that there was significantly higher N uptake by leaf, stem and cobs were recorded with application of 150 kg N ha^{-1} in three splits (161.6 kg N ha^{-1}) followed by LCC threshold 5 (164.2 kg N ha^{-1}) and NDVI-0.8 (154.2 kg N ha^{-1}).

Pandey *et al*. (2015) carried out an experiment to determine the effect of nitrogen level and its spilt application on leaf area index, crop growth rate and grain yield of spring maize under tillage systems in split-split plot design, taking tillage system (zero and conventional) as main factor, nitrogen levels (60, 120 and 180 kg N ha^{-1}) as sub plots while its split application (2 equal split and 4 equal split) was assigned as sub - sub plots was carried out. Leaf area index, crop growth rate and grain yield were not influenced by the tillage, but increased with increasing N levels and its split application. Leaf area index, crop growth rate and grain yield were highest at 180 kg N ha^{-1} than 120 kg N ha^{-1} and 60 kg N ha^{-1} applied plots. Similarly, these parameters were higher in four equal split applications than two equal split application of nitrogen. Application of 180 kg N ha^{-1} and its four equal split application increased leaf area index and crop growth rate enhancing grain yield of maize in both tillage systems.

Robert *et al*. (2015) reported that split application of nitrogen reduced nutrients supplied and increased efficiency and fertilization with suitable rate and time by split increased leaf area, dry matter accumulation, yield contributing characteristics and finally yield of maize.

Arun *et al*. (2014) reported that split application of nitrogen on growth and yield of maize (*Zea mays* L.) in the Madhya Pradesh was carried out during *kharif* season. The two years experiments results showed application of nitrogen through neem coated urea @ 100 kg/ha in 3 splits doses i.e. basal, 25 and 45 DAS was found more productive and profitable.

Niaz *et al.* (2014) reported that maximum plant height (167.69 cm) and leaf area index (2.98%) were obtained with S_3 (50% N broadcast-incorporated at seed bed preparation + 50% N top dressed at V_9 + C_2) which was at par with S_4 (25% N broadcast-incorporated at seed bed preparation + 75% N top dressed at V_9 + C_2), S_5 (100% N top dressed at V_9 + C_2), S_2 (25% N broadcast-incorporated at seed bed preparation + 75% N top dressed at V_9 + C_2) and S_1 (100% N broadcast-incorporated at seed bed preparation + C_2).

Hammad *et al.* (2013) conducted an experiment on different times of nitrogen application *viz.*, T_1 (1/3rd N at seed bed preparation, 1/3rd N at V6 and 1/3rd N at VT stage), T_2 (1/3rd at V_2 stage, 1/3rd at V_{16} and 1/3rd N at R_1 stage) and T_3 (1/3rd at seed bed preparation, 1/3rd N at V_{12} and 1/33rd N at R_2 stage) at Pakistan and concluded that time of nitrogen application did not significantly affect the number of days to emergence in both the years. T_3 took more days to tasseling, silking and maturity compared to other treatments.

Singh *et al*. (2013) conducted the experiment at Crop Research Station, Bahraich in winter seasons of 2008-09 and 2009-10 in randomized block design with three replications. The four treatments were-T_1-30% as basal, 10% at four leaf stage, 30% at 8 leaf stage and 30% at tasseling stage, T_2 -10% as basal, 20% at 4 leaf stage, 30% at 8 leaf stage 30% at tasseling stage and 10% at grain filling stage. T_3 -5% as basal, 30% at 4 leaf stage, 40% at 8 leaf stage 15% at tasseling stage and 10% at grain filling stage. T_4 - 20% as basal, 20% at 4 leaf stage 30% at 8 leaf stage 20% at tasseling stage and 5% at grain filling stage. Full dose of P and K was applied as basal and nitrogen' was applied as per treatments. The results indicated that highest plant height (197.0 cm.) was noted under T_1 treatment (30% as basal 10% at 4 leaf stage, 30% at 8 leaf stage and 30% at tasseling stage) which was significantly superior to other treatments.

Tadesse *et al.* (2013) reported that application of 128 kg N ha^{-1} in two equal split 1/3 N at planting and 2/3 at knee height significantly ($p<0.05$) out-yielded the other split applications. The application method gave a yield advantage of 1005 kg ha^{-1} over the commonly practiced 1/2 at planting and 1/2 at knee height application.

Ali *et al*. (2012) conducted an experiment on randomized complete block design with three replications at the Research Farm of University of Mohaghegh (Ardabili) during 2009 cropping season. Nitrogen rates were arranged in main plot with four levels including: 0, 75, 150 and 225 Kg N ha^{-1} and nitrogen application timing in sub plots by three levels including: (1/3 in planting + 1/3 in 8-10 leaf stages + 1/3 in tasseling initiation), (½ planting + ½ in tasseling initiation) and (½ in planting + ¼ in 8-10 leaf stages + ¼ in tasseling initiation) as T_1, T_2 and T_3, respectively. The highest grain yield (7928.6 Kg ha^{-1}) produced by combination of 225 Kg N ha^{-1} with N application timing as T_1.

Kaleem *et al*. (2012) reported that the split application of N showed a significant increase in both straw and grain yield (6%) over full basal N application. Splitting of N showed significant increase in N uptake by 6 and 13 %. The maximum NUE was observed between 68 and 70 % at 90 kg N per ha and there was a general trend of decreasing NUE with increasing N rates. Splitting N increased NUE by 14 %. Results of this experiment showed that application of 180 kg N ha^{-1} in split applications is a successful and sustainable management for maize production in rainfed condition.

Nemati and Sharifi (2012) conducted the experiment in that nitrogen rates were arranged in main plot with four levels including: 0, 75, 150 and 225 Kg N ha^{-1} and nitrogen application timing in sub plots by three levels including: (1/3 in planting + 1/3 in 8-10 leaf stages + 1/3 in tasseling initiation), (½ planting + ½ in tasseling initiation) and (½ in planting + ¼ in 8-10 leaf stages + ¼ in tasseling initiation) as T_1, T_2 and T_3 respectively. Results indicated that the highest grain yield (7928.6 kg ha^{-1}) produced by combination of 225 kg N ha^{-1} with N application timing as T_1.

Syed *et al*. (2012) conducted a study to know the effect of one time N application dose (140 kg N ha^{-1}) vs. two split (at planting and V_4), three split (at planting, V_4, and V_6), four splits (at planting, V_4, V_6 and V_8) and five split (at planting V_4, V_6, V_8 and V_{10}) on maize growth and biomass production was evaluated. The three splits of N fertilizer at a total rate of 140 kg per ha applied through fertigation at planting, V4 and V6 stages significantly increased number of leaves per plant, plant height, stem girth, biomass production, leaf area index, leaf area duration, crop growth rate, total dry matter production, N content and N uptake. Hence, it is thus recommended that three split N application of 140 kg per ha through fertigation at planting, V_4 and V_6 stages could be more efficient for achieving higher yield, good quality characters and maximum biomass production of maize.

Mburu *et al.* (2011) evaluated five maize varieties for two seasons in two semi-arid areas. Nitrogen fertilizer was applied as urea at 0 and 36 kg N ha^{-1}; the latter was split applied in equal quantities at 20 and 40 days after emergence. There were no significant differences in grain yield among the varieties between the sites within season but there were grain yield differences between the sites, split application and seasons. Grain yield response to nitrogen fertilizer was significant.

Hafiz *et al*. (2011) conducted a field experiment during 2009 at Agronomic Research Area, University of Agriculture, Faisalabad. Based on the results, it was concluded that application of N in three split (at V_2, V_{16} and R_1 stage) @ 250 kg ha^{-1} can be recommended for achieving optimum grain yield.

Hassan *et al*. (2010) conducted a field research experiment to assess the effect of methods (broadcast, fertigation and side dressing) in combination with different N splitting strategies (140 N kg ha^{-1}). The treatment of three splits of N fertilizer at a total rate of 140 kg ha^{-1} applied through fertigation at planting, V_4 and V_6 stages significantly increased number of leaves per plant, plant height, stem girth, biomass production ,leaf area index, leaf area duration, crop growth rate, total dry matter, N content and N uptake.

Suphasit *et al*. (2010) reported that split applications of fertilizer nitrogen improved the crop growth and yield of maize and reduced nutrient loss through leaching in sandy soils. But their effectiveness under high rainfall regimes to produce a maize growth response needs further investigation. Three to four split applications of the fertilizer increased the grain yield from 2.7 to 3.3–4.5 Mg ha^{-1}. There was a greater crop growth rate (CGR) and relative growth rate (RGR) with the split applications of fertilizer during 30–60 DAS after emergence (DAE). The highest agronomic efficiency (AE) resulted from a three-split application. However, application of fertilizer later than 45 DAS had no significant effect. The basal fertilizer application to 7–15 DAS increased the grain yield to 3.5–3.7 Mg ha^{-1}, whereas a pre–planting application produced a yield of 2.7 Mg ha^{-1}. The basal fertilizer application to 7–15 DAS improved the CGR, RGR and AE. These results indicated that fertilizer applications to minimize nutrient loss increased the growth and nutrient use efficiency of maize on sandy soil in a high rainfall regime

Saleem *et al*. (2009) evaluated the split dose of N application at different growth stages of crop plants (full N at sowing, half N at sowing + half N 25 DAS and 1/3 N at sowing + 1/3 N 25 DAS + 1/3 N at 55 DAS). Experimental result revealed that the maximum number of grains per cob (519.00), 100 grain weight (35.40 g) and grain yield (6.42 t ha^{-1}) were recorded when 1/3 N was applied at sowing + 1/3 N at 25 DAS and 1/3 N 55 DAS as compared to other timings of N application at different growth stages of crop.

Bindhani *et al*. (2007) conducted an experiment to study the effect of nitrogen levels (40, 80 and 120 kg N ha^{-1}) and timing of nitrogen application at pre tasselling along with no nitrogen (control) on productivity and nitrogen use efficiency of baby corn (*Zea mays* L.). Growth, yield attributes, baby corn yield, nitrogen content and uptake, protein content and yield, net return and benefit cost ratio increased significantly up to application of 120 kg N ha^{-1}.

Mollah *et al*. (2007) studied three urea application treatments which were T_1 (1/3 as basal + 1/3 at 8 leaves stage + 1/3 at tasseling stage), T_2 (30 % as basal + 70% at 8 leaves stage) and T_3 (50% as basal and 50% at 8 leaves stage). Plant height, no of filled grains/cob, 100 seed weight, grain yield and straw yield were highest in T_1 compared to others. On the other hand, the highest no of cob was found in T_1 and unfilled grain/cob in T_3. There was no significant difference for grain yield among the treatments. But comparatively the higher grain yield (6.27 t ha^{-1}) was obtained from treatment T_1.

Harikrishna *et al*. (2005) reported that application of 200 per cent RDN in three and four splits recorded significantly higher plant height, LAI, dry matter yield over 100% RDN and was on par with the treatment receiving 150% RDN in three and four splits of application.

According to Gehl *et al.* (2005) split application of nitrogen is the best management practices in order to match the crop needs with nitrogen availability which resulting into better yield.

Muthukumar *et al*. (2005) studied the effect of split application of nitrogen on the productivity of baby corn. Split application of nitrogen *viz.,* ½ basal + ½ N at 25 DAS, ½ basal + ½ at 45 DAS, ½ basal + ¼ at 25 DAS + ¼ at 45 DAS; and ¼ basal + ½ at 25 DAS

+ ¼ at 45 DAS were taken in sub plots. The results revealed that N in split doses effect on growth parameters of baby corn.

Ogoke *et al*. (2003) reported that application of nitrogen in two equal splits (at planting and tasselling stage) gave higher stover yield as compared to when nitrogen was applied first at three weeks after planting and second at tasselling stage in a humid tropical environment of Nigeria.

Rizwan *et al*. (2003) conducted a field studies to determine the effect of split application of nitrogen in maize (*Zea mays* L.) reported that the maximum plant height (240.13 cm) was recorded with the application of nitrogen in three splits, *viz*., at sowing, first irrigation and knee height.

CHAPTER III

MATERIALS AND METHODS

This part presents a concise depiction about the duration of the experimental period, site description, climatic state of the area, harvest or planting materials that are being utilized in the test, treatments, design, crop growing procedure, intercultural activities, data collection and statistical analyses.

3.1 Experimental period

The experiment was conducted during the period from October- 2021 to February-2022 in Rabi season.

3.2 Site description

3.2.1 Geographical location

The experiment was directed at the Agronomy field of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar Agargong Dhaka, Bangladesh. The experimental site is topographically situated at 23°77′ N scope and 90°33′ E longitude at an elevation of 8.6 meter above ocean level.

3.2.2 Agro-Ecological Zone

The experimental field belongs to the Agro-ecological zone (AEZ) of “The Modhupur Tract”, AEZ-28. This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as ‘islands’ surrounded by floodplain. For better understanding about the experimental site has been shown in the Map of AEZ of Bangladesh in Appendix-I. (Banglapedia, 2014)

3.3 Climate and weather

The climate of the experimental site was subtropical, characterized by the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Meteorological data related to the temperature, relative humidity and rainfall during the experiment period of was collected from Bangladesh Meteorological Department (Climate division), Sher-e-Bangla Nagar, Dhaka and has been presented in Appendix- II.

3.4 Soil

The soil of the experimental pots belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon soil series. Soil pH ranges from 5.4–5.6 (Anon., 1989). The land was above flood level and sufficient sunshine was available during the experimental period. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix-III (Biswas *et al*., 2019).

3.5 Planting materials

In this research work, seeds of "SAUWMOPT" of white maize genotypes were used as planting material which was collected from the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh.

3.6 Treatment of the experiment

The experiment consists of two factors which are given below:

Factor A: Earthing up practices (2 types)

E_0= No earthing up,

E_1= Earthing up at 45 DAS,

Factor B: Application method of nitrogen fertilizer (3 types)

N_1= Side dressing at 85 DAS,

N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS, and

N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS.

3.7 Experimental design

The experiment was laid out in the split-plot design with three replications. The field was divided into 3 blocks to represent 3 replications. Total 18 unit plots were made for the experiment with 6 treatments. The size of each unit plot was 3.89 m^2 (3.17 m × 1.23 m).

Distance maintained between replication and plots were 1.0 m and 0.50 m, respectively. Layout of the experimental field was presented in Appendix IV.

3.8 Detail of experimental preparation

3.8.1 Preparation of experimental land

The land was opened with the help of a tractor drawn disc harrow on (19 October 2021) and then ploughed with rotary plough twice followed by laddering to achieve a medium tilth required for the crop under consideration. All weeds and other plant residues of previous crop were removed from the field. Immediately after final land preparation, the field layout was made on (19 October 2021) according to experimental specification. Individual plots were cleaned and finally the plot were prepared.

3.8.2 Fertilizer application

Manures and fertilizers were used according with par treatments requirements. The recommended dose of maize fertilizer by BARI Krishi Projukti Hatboi is as follows:

Fertilizers	Dose ha^{-1}
Cowdung	10 ton
Urea	400 kg
Triple super phosphate	200 kg
Gypsum	190 kg
Muriate of potash	200 kg
Zinc sulphate	10 kg
Boric acid	10 kg

(BARI, 2019)

The whole amounts of fertilizers were applied as basal doses except urea. Urea fertilizer were applied according with par treatment requirement.

3.8.3 Seed sowing and maintaining spacing

The maize seeds were sown in lines maintaining 60 cm × 20 cm row to row and plan to plant spacing, having 2 seeds $hole^{-1}$ under direct sowing in the well prepared plot on 20 October 2021.

3.9 Intercultural operations

After raising seedlings, various intercultural operations such as irrigation, weeding, gap filling and thinning, drainage, pest and disease control etc. were accomplished for better growth and development of the maize seedlings.

3.9.1 Gap filling and thinning

Gap filling was done at seventh day after sowing to maintain uniform plant population. Thinning was done two weeks after the sowing in order to maintain required plant density in each plot. By pulling out the excess seedlings in each spot, one seedling retained at each spot to maintain optimum plant population per plot.

3.9.2 Weed management

To check the weed growth, two inter cultivations were done during fourth and sixth week after sowing with the help of blade hoe and two hand weeding were carried out at 25 and 45 days after sowing.

3.9.3 Water management

Protective irrigation was provided to the crop depending upon the soil moisture content and prevailing weather conditions during the period of experiment. Five irrigations were given for the entire crop growth to avoid moisture stress.

3.9.4 Earthing up

Earthing up were done according with par treatment requirement. Earthing up helped to give the better anchorage and favorable environment for root growth and development. It also helped to loosen the soil, to reduce the bulk density and to increase the water holding capacity of the soil**.**

3.9.5 Plant protection measure

Plant protection measures was adopted where ever they found necessary during the crop growth period. Chloropyriphos spray 2.5ml lt^{-1} was sprayed against the control of stem borer (*Chilo tumidicostalis*).

3.9.6 Harvesting

The crop was harvested after attaining the physiological maturity at 110 days after sowing from all the plots. The cobs were picked up when ears were of full size, had tight husk and somewhat dried silks. At this stage, kernels were fully developed and exuded a milky liquid when punctured. The crop was harvested at milky stage by removing the cobs from the plot in the net plot area. Harvesting was done on 20 February 2022.

3.10 Data collection

Data on various parameters were collected from the sample plants. To avoid the border effect and achieve the highest level of accuracy, five plants were chosen at random from each plot to collect data. For this, the outside rows and the outer plants in the middle rows were avoided.

3.11 Collection of different data

Data were collected on the following parameters:

i. Plant height (cm)
ii. Number of leaves plant^{-1}
iii. Total dry matter plant^{-1} (g) at harvest
iv. Cob length (cm)
v. Cob circumference (cm)
vi. Number of rows cob^{-1}
vii. Number of grains cob^{-1}
viii. 1000 grain weight
ix. Grain yield (t ha^{-1})
x. Stover yield (t ha^{-1})
xi. Biological (t ha^{-1})
xii. Harvest index (%)

3.12 Procedure of recording data

A brief outline on data recording procedure followed during the study was given below:

i. Plant height (cm)

At different stages of crop growth (30, 60, 90 DAS, and at harvest), the height of five randomly selected plants from the inner rows per plot was measured from ground level to the tip of the plant portion and the mean value of plant height was recorded in cm.

ii. Number of leaves plant^{-1}

At different stages of crop growth (30, 60, 90 DAS, and at harvest), the number of leaves of five randomly selected plants from the inner rows per plot was measured by counting the number of leaves of the plant and the mean value of the number of leaves was recorded.

iii. Dry matter weight plant^{-1}

At harvest 5 plants from each plot were uprooted randomly. Then the plant was cut into pieces. Then the various pieces of the plant were put into a paper packe,in case of harvesting, cob was also put into a packet and placed in oven maintaining 70^0 C for 72 hours. Then the sample was transferred into desiccators and allowed to cool down at room temperature. Then the sample weight was taken and then calculate the total dry matter of a plant for each plot. It was performed at harvest.

iv. Cob length (cm)

Cob length was measured in centimeter. Cob length was measured from the base to the tip of the cob of the five selected plants in each plot with the help of a centimeter scale then average data were recorded.

v. Cob circumference (cm)

Cob circumference measured in centimeter from the base, middle and top portion of the ear and averaged.

vi. Number of grain rows cob^{-1}

Five cobs from each plot were selected randomly and the number of grain rows cob^{-1} was counted. Then the average result was recorded.

vii. Number of grains cob^{-1}

The numbers of grains per cob was measured from the base to tip of the ear collected from five randomly selected cobs of each plot and finally average result was recorded.

viii. 1000-grain weight

After removing the grain from each cob from each plot grains are stored in a specific grain stock or pot. From the seed stock of each plot 1000 seeds were calculated and the weight was measured by an electrical balance. It was recorded in gram.

ix. Grain yield (t ha^{-1})

After removing the grain from the cob, grain yield was calculated. Grain yield was calculated from cleaned and well dried grains collected from 1 m^2 area of each plot and expressed as t ha^{-1}.

x. Stover yield (t ha^{-1})

After separation of grains from shell, all the parts except grains from harvested area was sun dried and the weight was recorded and then converted into t ha^{-1}.

xi. Biological yield (t ha^{-1})

Seed yield and Stover yield together were regarded as biological yield. The biological yield was calculated with the following formula:
Biological yield = Seed yield + Stover yield.

xii. Harvest Index (%)

Harvest Index indicate the ratio of economic yield (grain yield) to biological yield and was calculated with the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Grain weight}}{\text{Biological weight}} \times 100$$

3.13 Statistical data analysis

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program Statistix 10 software. The significant differences among the treatment means were compared by Least Significant Difference (LSD) at 5% levels of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

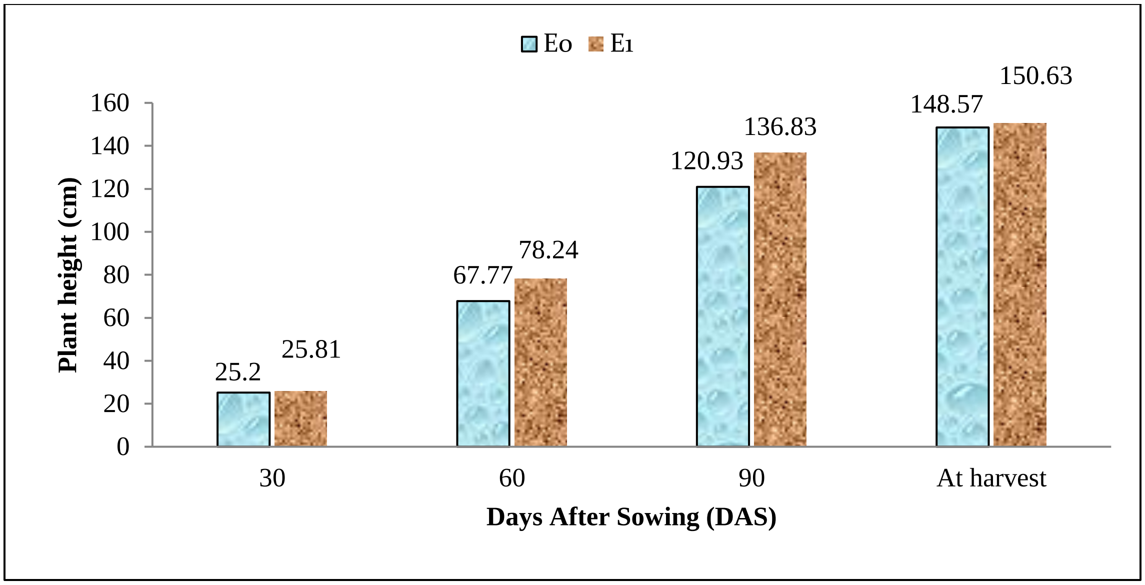
Results obtained from the present study have been presented and discussed in this chapter with a view to study the growth and yield of white maize as influenced by earthing up practices and application methods of nitrogen fertilizer. The results have been discussed, and possible interpretations are given under the following headings.

4.1 Plant growth parameters

4.1.1 Plant height (cm)

Effect of different earthing up practices

Plant height is an essential character of the vegetative stage of the crop plant and indirectly impacts on yield of crop plants. Different earthing up practices significantly influenced on plant height of white maize at 60, 90 DAS respectively. It was seen that height increased gradually with the age of the crop up to harvest. The plant height reached the highest value at harvest (Figure 1). Experimental result revealed that the highest plant height (25.81, 78.24, 136.83 and 150.63 cm) at 30, 60, 90 DAS and at harvest, respectively was observed in E_1 treatment, while the lowest plant height (25.20, 67.77, 120.93 and 148.57 cm) at 30, 60, 90 DAS and at harvest, respectively was observed in E_0 treatment. The variation in plant height could be attributed primarily to the beneficial effect of earthing up and proper placement of top dressed fertilizers on maize plant growth. Similar result also observed by Bhatnagar and Kumar (2017) who reported that the earthing up operation in maize has produced a remarkable effect on plant height of maize as compared to no earthing treatment.

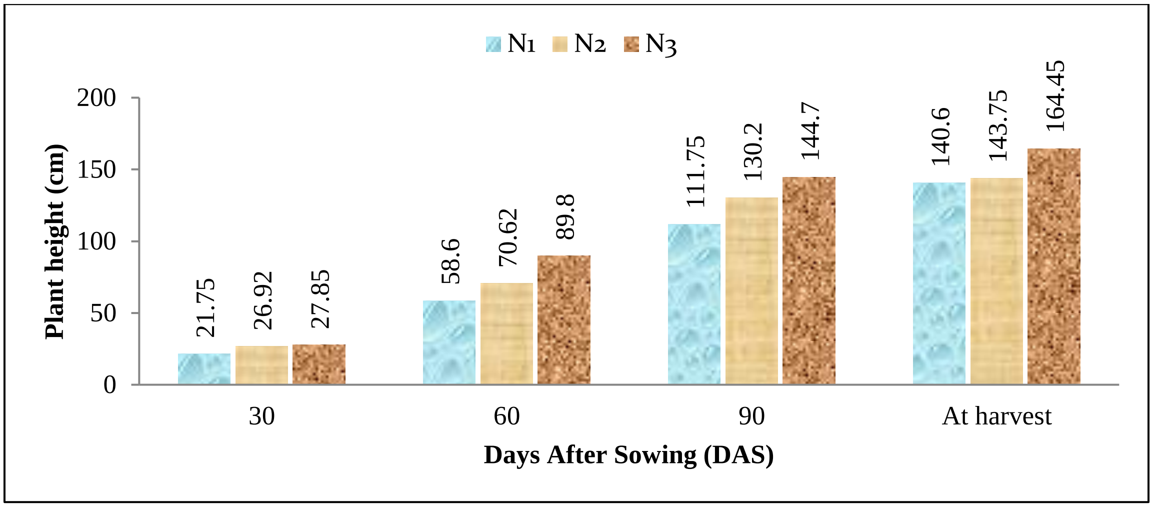


Here, E_0= No earthing up, E_1= Earthing up at 45 DAS.

Figure 1. Effect of different earthing up practices on the plant height of white maize at different days after sowing ($LSD_{(0.05)}$: Ns, 4.14, 14.77 and Ns at 30, 60, 90 DAS and at harvest, respectively).

Effect of application methods of nitrogen fertilizer

Significant variance in white maize plant height was observed at different days after sowing as result of different methods of nitrogen fertilizer application at (Figure 2). Experimental result showed that the highest plant height of white maize (27.85, 89.80, 144.70 and 164.45 cm) at 30, 60, 90 DAS and at harvest, respectively was observed in N_3 treatment, which was statistically similar with N_2 (26.92 cm) treatment at 30 DAS. While the lowest plant height of white maize (21.75, 58.60, 111.75 and 140.60 cm) at 30, 60, 90 DAS and at harvest, respectively was observed in N_1 treatment, which was statistically similar with N_2 (143.75 cm) treatment at harvest, respectively. Because of late germination and an initial very slow growth rate in the winter season, high amounts of nitrogen at the basal may not be fully utilized by the plants. Whereas splitting application resulted in better nitrogen utilization by the plants, which improved the growth and yield attributes of maize. Optimal and regular supply of nitrogen at different growth stages of maize crop resulted in better utilization of nitrogen by the plants, which improved the growth and yield attributes. The result was similar with the finding of Harikrishna *et al*. (2005) who reported that application of 200 per cent RDN in three and four splits recorded significantly higher plant height, LAI, dry matter yield over 100% RDN and was on par with the treatment receiving 150% RDN in three and four splits of application.



Here, N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS.

Figure 2. Effect of application methods of nitrogen fertilizer on the plant height of white maize at different days after sowing ($LSD_{(0.05)}$: 1.13, 4.64, 6.63 and 10.92 at 30, 60, 90 DAS and at harvest, respectively).

Combined effect of earthing up practices and application methods of nitrogen fertilizer

Combined effect of earthing up practices and application methods of nitrogen fertilizer had shown significant effect on plant height of white maize at different days after sowing (Table 1). The results of the experiment showed that the E_1N_3 treatment combination gave the highest plant height (28.30, 92.70, 153.70 and 168.80 cm) at 30, 60, 90 DAS and at harvest, respectively which was statistically similar with E_1N_2 (26.87 cm), E_0N_3 (27.40 cm) and E_0N_2 (26.97 cm) at 30 DAS; with E_0N_3 (86.90 cm) at 60 DAS and with E_0N_3 (160.10 cm) and E_0N_2 (150.50 cm) treatment combination at harvest respectively. While the lowest plant height (21.24, 52.47, 103.90 and 135.10 cm) at 30, 60, 90 DAS and at harvest, respectively was observed in E_0N_1 combination treatment, which was statistically similar with E_1N_2 (26.97 cm) at 30 DAS and with E_1N_1 (146.10 cm) and E_1N_2 (137.00 cm) treatment combination at harvest respectively.

Table 1. Combined effect of earthing up practices and application methods of nitrogen fertilizer on the plant height of white maize at different DAS

Treatment combinations	Plant height (cm) at			
	30	60	90	At harvest
E_0N_1	21.24 b	52.47 d	103.90 d	135.10 c
E_0N_2	26.97 a	63.93 c	123.20 bc	150.50 a-c
E_0N_3	27.40 a	86.90 a	135.70 b	160.10 ab
E_1N_1	22.27 b	64.73 c	119.60 c	146.10 bc
E_1N_2	26.87 a	77.30 b	137.20 b	137.00 c
E_1N_3	28.30 a	92.70 a	153.70 a	168.80 a
$LSD_{(0.05)}$	1.60	6.56	15.33	18.63
CV(%)	3.33	4.78	5.38	5.49

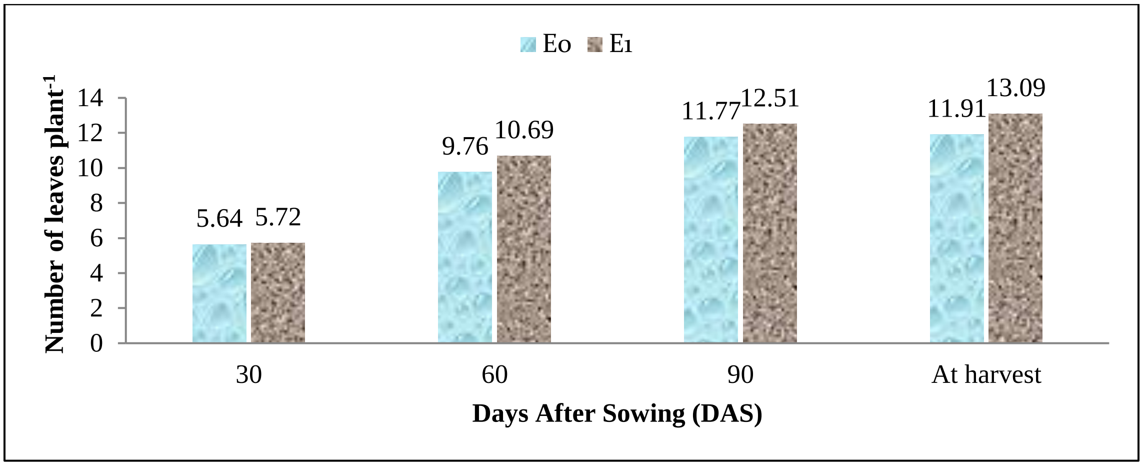
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, E_0= No earthing up, E_1= Earthing up at 45 DAS, N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS.

4.1.2 Number of leaves plant^{-1}

Effect of different earthing up practices

Different earthing up practices significantly influenced on number of leaves plant^{-1} of white maize at 60, 90 DAS and at harvest, respectively (Figure 1). Experimental result revealed that the highest number of leaves plant^{-1} of white maize (5.72, 10.69, 12.51 and 13.09) at 30, 60, 90 DAS and at harvest, respectively was observed in E_1 treatment, while the lowest number of leaves plant^{-1} of white maize (5.64, 9.76, 11.77 and 11.91) at 30, 60, 90 DAS and at harvest, respectively was observed in E_0 treatment. This increased number of leaves plant^{-1} of white maize was primarily due to the beneficial effect of earthing up on maize plant growth and development, as well as proper placement of top dressed fertilizers.

Similar result also observed by Nath *et al.* (2022) who reported that earthing up practices improved growth and yield characteristics of maize.

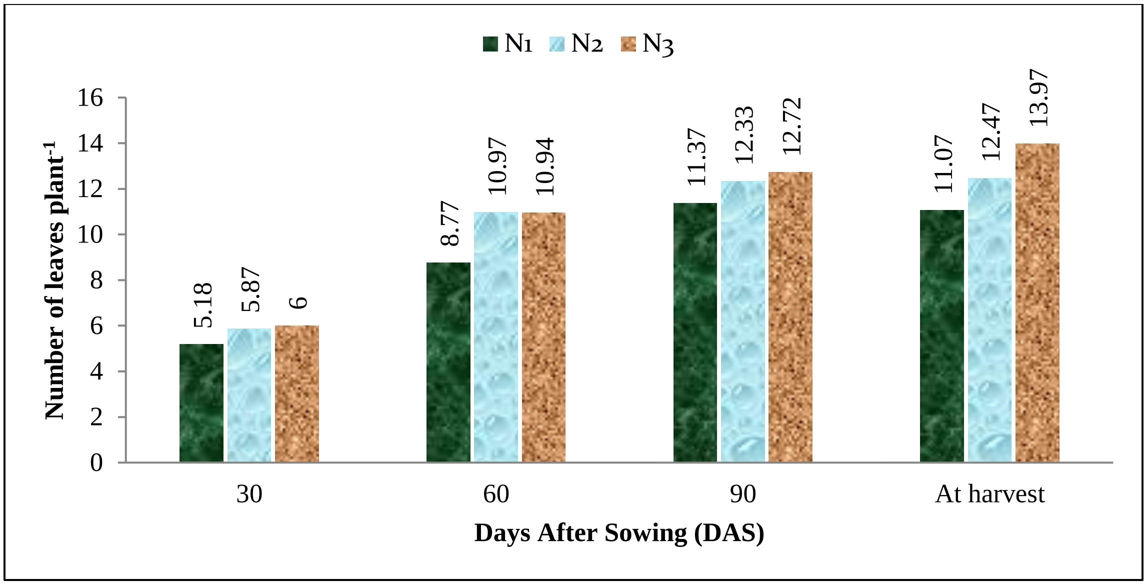


Here, E_0= No earthing up, E_1= Earthing up at 45 DAS.

Figure 3. Effect of different earthing up practices on the number of leaves plant^{-1} of white maize at different days after sowing ($LSD_{(0.05)}$: Ns, 0.72, 0.08 and 0.15 at 30, 60, 90 DAS and at harvest, respectively).

Effect of application methods of nitrogen fertilizer

The number of leaves on maize plant varied significantly at different days after sowing depending on the nitrogen fertilizer application methods (Figure 4). Experimental result showed that the highest number of leaves plant^{-1} of white maize (6.00, 10.94, 12.72 and 13.97) at 30, 60, 90 DAS and at harvest, respectively was observed in N_3 treatment, which was statistically similar with N_2 (10.97) treatment 60 DAS. While the lowest number of leaves plant^{-1} of white maize (5.18, 8.77, 11.37 and 11.07) at 30, 60, 90 DAS and at harvest, respectively was observed in N_1 treatment. When compared to conventional application, regular supply of nitrogen fertilizer throughout the growing period under a greater number of splits resulted in significant improvement in plant growth and development. The result was similar with the findings of Hafiz *et al*. (2011) who reported that application of N in three split (at V_2, V_{16} and R_1 stage) @ 250 kg ha^{-1} can be recommended for achieving optimum growth (plant height, leaves number) and grain yield of maize.



Here, N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS.

Figure 4. Effect of application methods of nitrogen fertilizer on the number of leaves plant^{-1} of white maize at different days after sowing ($LSD_{(0.05)}$: 0.04, 0.41, 0.07 and 0.10 at 30, 60, 90 DAS and at harvest, respectively).

Combined effect of earthing up practices and application methods of nitrogen fertilizer

White maize leaf number at various days after sowing had shown significant impact depending on the combined effect of earthing up practices and application methods of nitrogen fertilizer (Table 2). The results of the experiment showed that the E_1N_3 treatment combination gave the highest number of leaves number plant^{-1} (6.07, 11.20, 13.13 and 14.33) at 30, 60, 90 DAS and at harvest, respectively which was statistically similar with E_1N_2 (11.13), E_0N_3 (10.67) and E_0N_2 (10.80) treatment combination at 60 DAS. While E_0N_1 treatment combination showed the lowest number of leaves number plant^{-1} (5.13, 7.80, 10.87 and 10.60) at 30, 60, 90 DAS and at harvest, respectively.

Table 2. Combined effect of earthing up practices and application methods of nitrogen fertilizer on the number of leaves plant^{-1} of white maize at different DAS

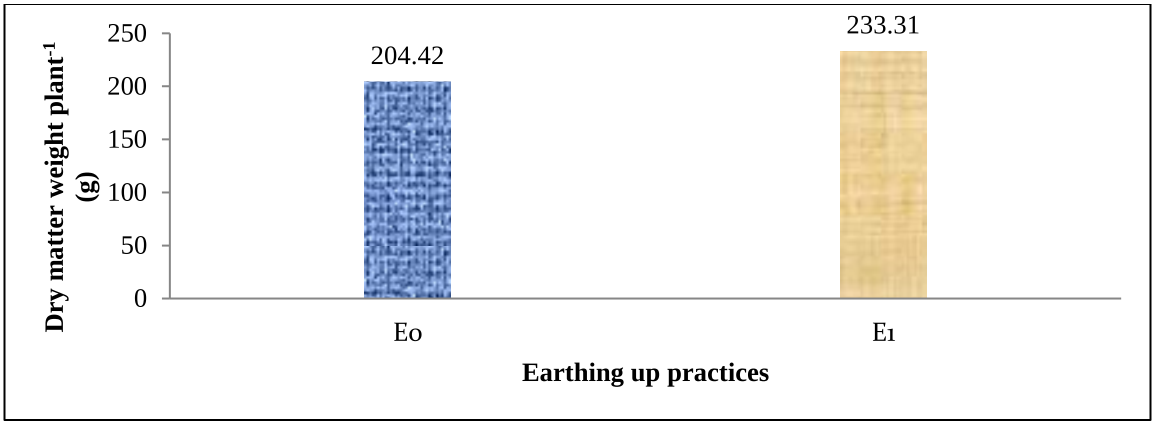
Treatment combinations	Number of leaves plnat^{-1} at			
	30	60	90	At harvest
E_0N_1	5.13 c	7.80 c	10.87 f	10.60 e
E_0N_2	5.87 b	10.80 a	12.13 d	11.53 d
E_0N_3	5.93 b	10.67 a	12.30 c	13.60 b
E_1N_1	5.23 c	9.73 b	11.87 e	11.53 d
E_1N_2	5.87 b	11.13 a	12.53 b	13.40 c
E_1N_3	6.07 a	11.20 a	13.13 a	14.33 a
$LSD_{(0.05)}$	0.11	0.82	0.11	0.18
CV(%)	2.64	3.06	4.5	2.61

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, E_0= No earthing up, E_1= Earthing up at 45 DAS, N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS.

4.1.3 Dry matter weight plant^{-1} (g)

Effect of different earthing up practices

Due to the various earthing up practices, the dry matter weight plant^{-1} of white maize at harvest had significantly changed (Figure 5). According to the experimental result, the highest dry matter weight plant^{-1} (233.31 g) of white maize was observed in E_1 treatment, while the lowest dry matter weight plant^{-1} (204.42 g) of white maize was observed in E_0 treatment. Dry weight plant^{-1} might have varied because early earthing up during the plant's active growth period enhanced the soil's nutrient absorption capabilities. similar result also observed by Islam *et al.* (2017) who reported that in maize crop the treatment M_2 (earthing up at 25 days after emergence) recorded higher values of total dry matter accumulation compared to other treatments.

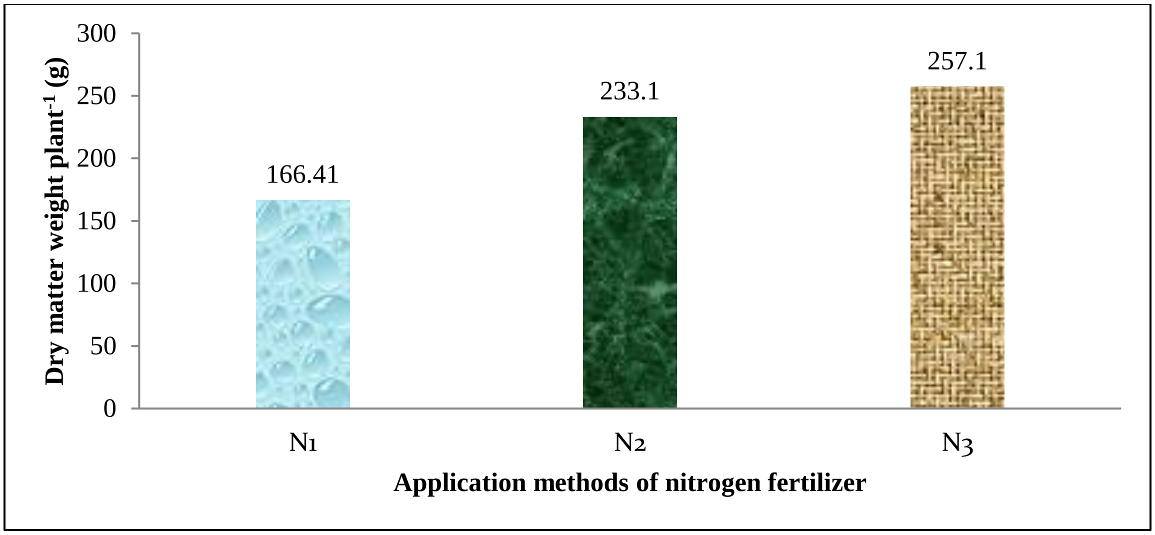


Here, E_0= No earthing up, E_1= Earthing up at 45 DAS.

Figure 5. Effect of different earthing up practices on the dry matter weight plant^{-1} of white maize at harvest ($LSD_{(0.05)}$: 16.57).

Effect of application methods of nitrogen fertilizer

The methods of applying nitrogen fertilizer had a significant impact on the dry matter weight plant^{-1} of white maize at harvest (Figure 6). Experimental result revealed that, the highest, dry matter weight plant^{-1} (257.10 g) of white maize was observed in N_3 treatment, while the lowest dry matter weight plant^{-1} (166.41 g) of white maize was observed in N_1 treatment. This was probably due to fact that, split application helps to improve the efficiency of nitrogen use by the plant, and can also help to reduce the risk of nitrogen loss from the soil. Robert *et al*. (2015) reported that split application of nitrogen reduced nutrients supplied and increased efficiency and fertilization with suitable rate and time by split increased leaf area, dry matter accumulation, yield contributing characteristics and finally yield of maize. Harikrishna *et al*. (2005) reported that application of 200 per cent RDN in three and four splits recorded significantly higher plant height, LAI, dry matter yield over 100% RDN and was on par with the treatment receiving 150% RDN in three and four splits of application.



Here, N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS.

Figure 6. Effect of application methods of nitrogen fertilizer on the dry matter weight plant^{-1} of white maize at harvest ($LSD_{(0.05)}$: 10.87).

Combined effect of earthing up practices and application methods of nitrogen fertilizer

The dry matter weight plant^{-1} of white maize at harvest was significantly influenced by the combined effect of earthing up practices and application methods of nitrogen fertilizer (Table 5). According to the experimental findings, the highest dry matter weight plant^{-1} of white maize (270.53 g) was observed in E_1N_3 treatment combination, while the lowest dry matter weight plant^{-1} of white maize (153.93 g) was observed in E_0N_1 treatment combination.

Table 3. Combined effect of earthing up practices and application methods of nitrogen fertilizer on the dry matter weight plant^{-1} white maize at harvest

Treatment combinations	Dry matter weight plant^{-1} (g)
E_0N_1	153.93 e
E_0N_2	215.67 c
E_0N_3	243.67 b
E_1N_1	178.88 d
E_1N_2	250.53 b
E_1N_3	270.53 a
$LSD_{(0.05)}$	19.81
CV(%)	5.73

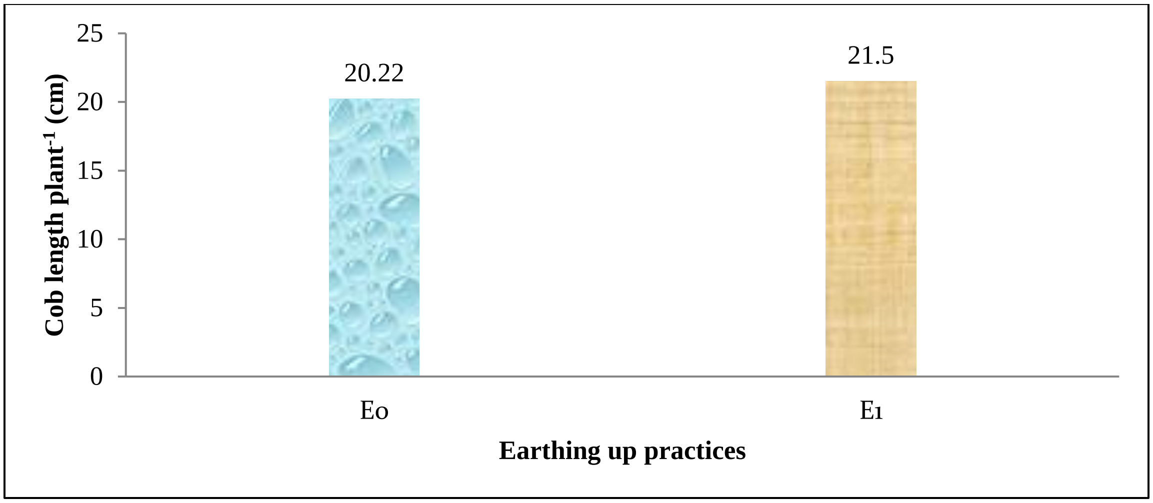
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, E_0= No earthing up, E_1= Earthing up at 45 DAS, N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS.

4.2 Yield contributing characters

4.2.1 Cob length plant^{-1} (cm)

Effect of different earthing up practices

The different earthing up practices had shown significant effect on the cob length plant^{-1} of white maize at harvest (Figure 7). According to the experimental findings the E_1 treatment recorded the longest cob length plant^{-1} (21.50 cm) of white maize. Whereas the lowest cob length plant^{-1} (20.22 cm) of white maize was observed in E_0 treatment.

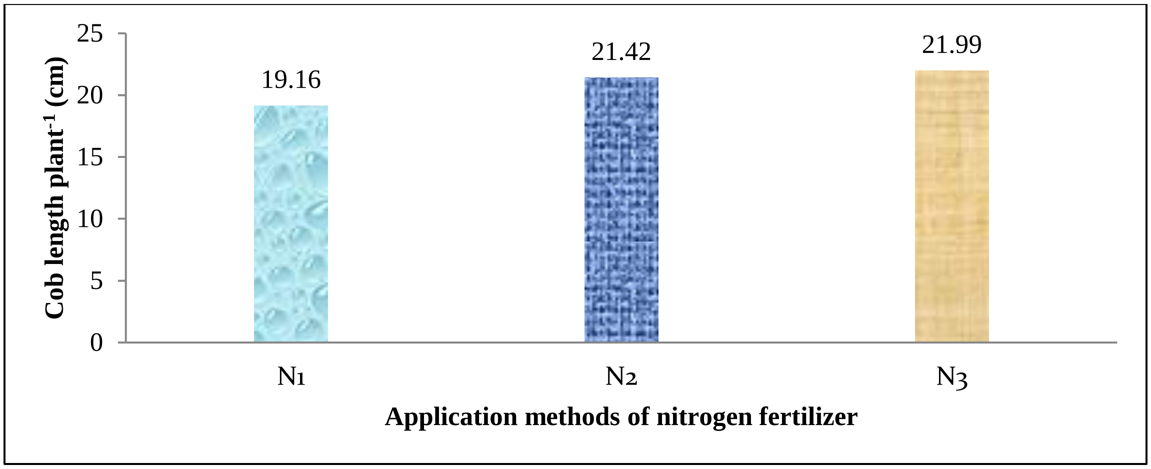


Here, E_0= No earthing up, E_1= Earthing up at 45 DAS.

Figure 7. Effect of different earthing up practices on the cob length plant^{-1} of white maize at harvest (LSD$_{(0.05)}$: 1.15).

Effect of application methods of nitrogen fertilizer

Significant variance in maize cob length at harvest was observed as a result of various methods of nitrogen fertilizer application (Figure 8). Experimental result showed that the highest cob length plant^{-1} (21.99 cm) of white maize was observed in N_3 treatment, which was statistically similar with N_2 (21.42 cm) treatment. Whereas the lowest cob length plant^{-1} (19.16 cm) of white maize was observed in N_1 treatment. The recorded cob length of maize after harvesting indicated that, the bulb cob length of maize was positively influenced by split application of nitrogen. Maize is fairly long duration crop and by split application, nitrogen was made available to the plants when they needed it most and thus the nutrients were utilized more effectively result in increased cob length plant^{-1} of maize. The result was similar with the find of Gharge *et al.* (2020) who reported that, the application of 50% N at basal and remaining nitrogen as per Leaf Colour Chart (LCC) has produced maximum cob length of maize.



Here, N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS.

Figure 8. Effect of application methods of nitrogen fertilizer on the cob length plant^{-1} of white maize at harvest (LSD$_{(0.05)}$: 0.68).

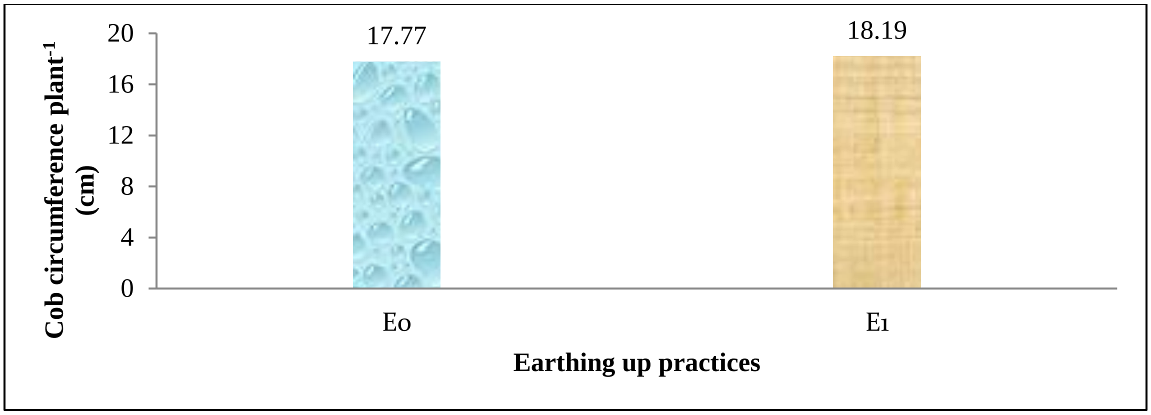
Combined effect of earthing up practices and application methods of nitrogen fertilizer

Cob length plant^{-1} of maize was significantly influenced by the combined effect of earthing up practices and application methods of nitrogen fertilizer (Table 4). Experimental result revealed that the highest cob length plant^{-1} (22.66 cm) of white maize was observed in E_1N_3 combination treatment, which was statistically similar with E_1N_2 (21.69 cm) combination treatment. Whereas the lowest cob length plant^{-1} (18.16 cm) of white maize was observed in E_0N_1 combination treatment.

4.2.2 Cob circumference plant^{-1} (cm)

Effect of different earthing up practices

The cob circumference plant^{-1} at harvest of white maize was shown non significant variation due to the effect of different earthing up practices (Figure 9). The experimental results showed that the E_1 treatment had the highest cob circumference plant^{-1} (18.19 cm). However, the E_0 treatment had the lowest cob circumference plant^{-1} (17.77 cm). This is also attributed to the fact that the cob circumference plant^{-1} of white maize is a genetic character of maize plant and it does not get affected by external influence.

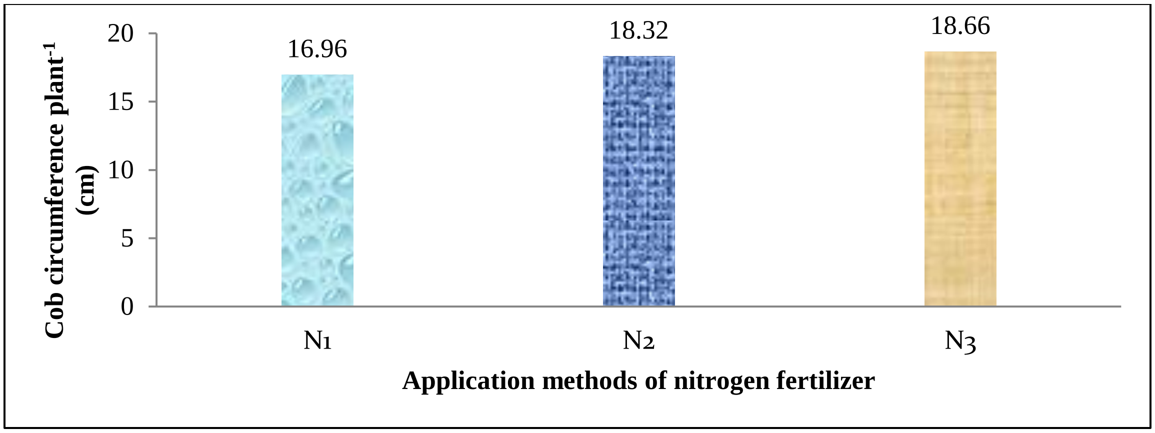


Here, E_0= No earthing up, E_1= Earthing up at 45 DAS.

Figure 9. Effect of different earthing up practices on the cob circumference plant^{-1} of white maize at harvest ($LSD_{(0.05)}$: 0.49).

Effect of application methods of nitrogen fertilizer

Nitrogen fertilizer application methods significantly influenced the cob circumference plant^{-1} of white maize at harvest (Figure 10). Experiment result revealed that, the highest cob circumference plant^{-1} of white maize at harvest (18.66 cm) was observed in N_3 treatment which was statistically similar with N_2 (18.32 cm) treatment. While the lowest cob circumference plant^{-1} of white maize at harvest (16.96 cm) was observed in N_1 treatment (Figure 4). Nitrogen is an important major nutrient of maize which favorablyinfluence the protein synthesis, carbohydrate metabolism and ultimatelytranslocation and storage food material in to the maize cob. Further, increase in cob circumference plant^{-1} of white maize was probably due to increase uptake of nutrients, which might have enhanced the photosynthesis and translocation of photosynthates to the cob, the storage organ of the maize which ultimately increased the cob circumference plant^{-1} of white maize. Therefore, split nitrogen application at proper timing result in proper nutrient supply in the root zone which was easily utilized by the plant comparable to others treatments. The result was similar with the findings of Robert *et al*. (2015) who reported that split application of nitrogen reduced nutrients supplied and increased efficiency and fertilization with suitable rate and time by split increased leaf area, dry matter accumulation, yield contributing characteristics and finally yield of maize.



Here, N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS.

Figure 10. Effect of application methods of nitrogen fertilizer on the cob circumference plant^{-1} of white maize at harvest ($LSD_{(0.05)}$: 0.58).

Combined effect of earthing up practices and application methods of nitrogen fertilizer

The combined effect of earthing up practices and nitrogen fertilizer application methods had shown significant effect on the cob circumference plant^{-1} of white maize at harvest (Table 4). The highest cob circumference plant^{-1}of white maize at harvest (19.16 cm) was observed in the E_1N_3 combination treatment, which was statistically comparable to the E_1N_2 (18.49 cm) combination treatment. While in the E_0N_1 combination treatment, white maize had the lowest cob circumference plant^{-1} (16.90 cm) which was statistically comparable to the E_1N_1 (16.93 cm) combination treatment.

Table 4. Combined effect of earthing up practices and application methods of nitrogen fertilizer on the cob length and cob circumference plant^{-1} of white maize at harvest.

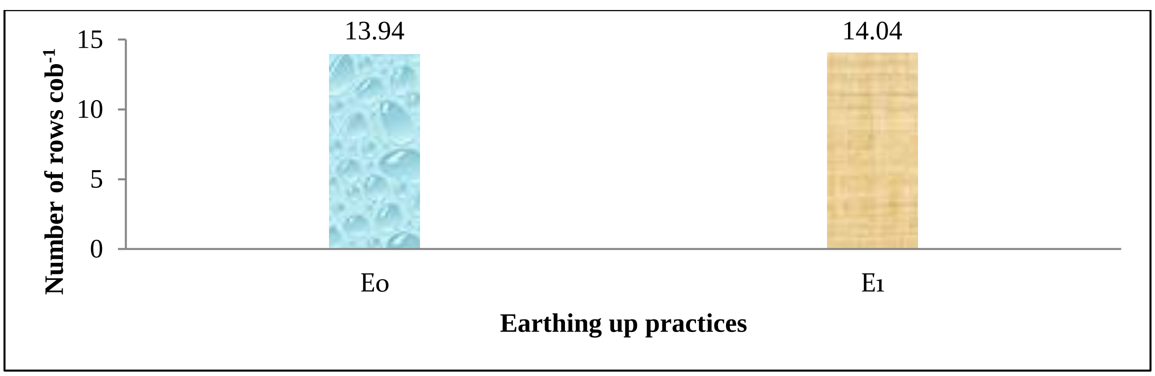
Treatment combinations	Cob length plant^{-1} (cm)	Cob circumference plant^{-1} (cm)
E_0N_1	18.16 d	16.90 c
E_0N_2	21.16 b	18.16 b
E_0N_3	21.33 b	18.16 b
E_1N_1	20.16 c	16.93 c
E_1N_2	21.69 ab	18.49 ab
E_1N_3	22.66 a	19.16 a
$LSD_{(0.05)}$	0.96	0.81
CV(%)	4.45	4.74

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, E_0= No earthing up, E_1= Earthing up at 45 DAS, N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS.

4.2.3 Number of rows cob^{-1}

Effect of different earthing up practices

Different earthing up practices on white maize had shown non significant effect on the number of rows cob^{-1} (Figure 11). According to the experimental findings, the highest number of rows cob^{-1} of white maize (14.04) was observed in E_1 treatment, while the lowest number of rows cob^{-1} of white maize (13.94) was observed in E_0 treatment.

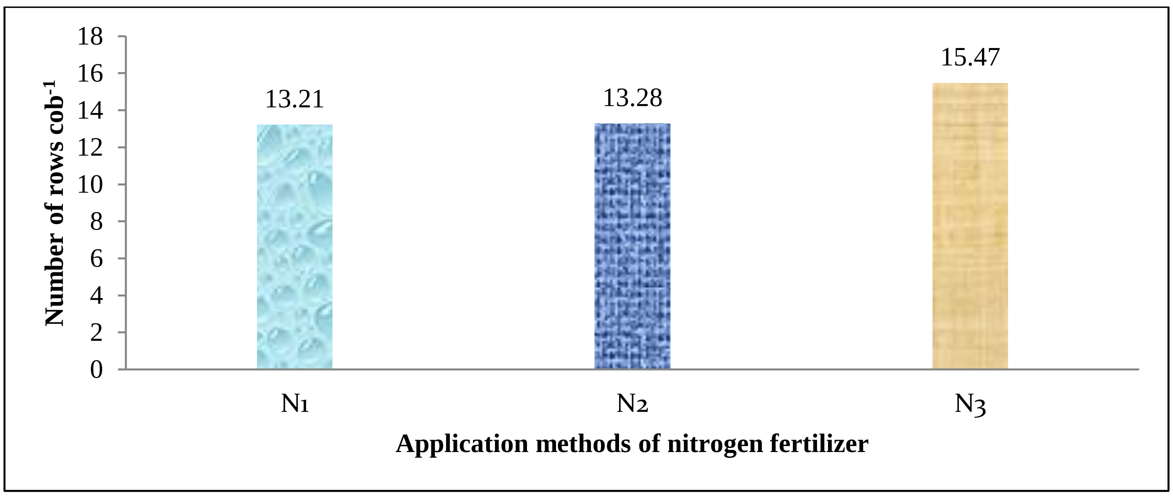


Here, E_0= No earthing up, E_1= Earthing up at 45 DAS.

Figure 11. Effect of different earthing up practices on the number of rows cob^{-1} of white maize at harvest ($LSD_{(0.05)}$: Ns).

Effect of application methods of nitrogen fertilizer

The application methods of nitrogen fertilizer on the number of rows cob^{-1} of white maize was found to be significant (Figure 12). Experimental result revealed that, the highest number of rows cob^{-1} of white maize (15.47) was observed in N_3 treatment, while the lowest number of rows cob^{-1} of white maize (13.21) was observed in N_1 treatment, which was statistically similar with N_2 (13.28) treatment. The split nitrogen fertilizer application, which encourages plants to take up nutrients sequentially, caused the variation in the number of rows cob^{-1} of white maize. This increased plant growth by increasing leaf area and number, which resulted in higher photo assimilates and, as a result, increased dry matter accumulation, which increased the number of rows cob^{-1} of white maize. The result obtained from the present study was similar with the findings of Gehl *et al.* (2005) who reported that the split application of nitrogen is the best management practices in order to match the crop needs with nitrogen availability which resulting into better growth and yield of corn.



Here, N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS.

Figure 12. Effect of application methods of nitrogen fertilizer on the number of rows cob^{-1} of white maize at harvest ($LSD_{(0.05)}$: 0.54).

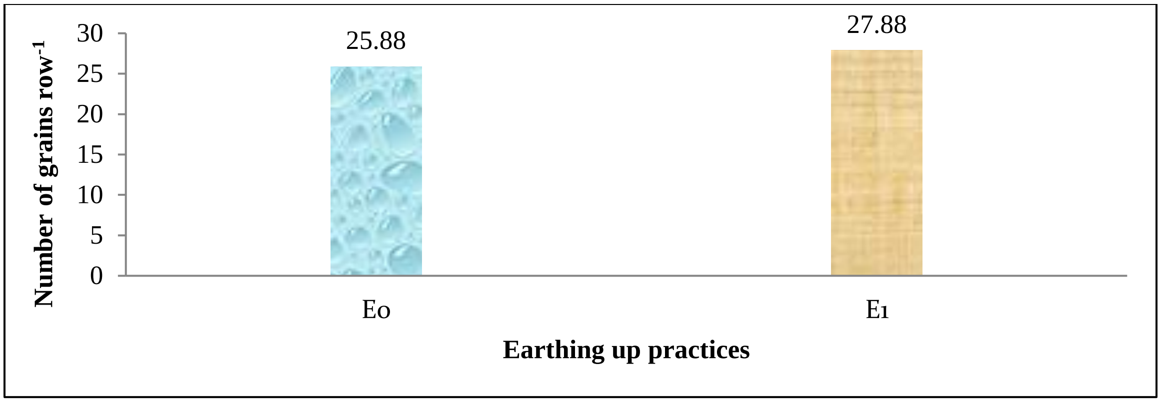
Combined effect of earthing up practices and application methods of nitrogen fertilizer

The number of rows cob^{-1} of white maize at harvest significantly influenced as a result of the combined effect of earthing up practices and application method of nitrogen fertilizer (Table 5). The experimental findings revealed that the E_1N_3 treatment combination had the highest number of rows cob^{-1} (15.67) of white maize, which was statistically similar with E_0N_3 (15.28) treatment combination. While the lowest number of rows cob^{-1} (13.09) of white maize was observed in E_0N_1 treatment combination, which was statistically similar with E_0N_2 (13.45), E_1N_1 (13.33) and E_1N_2 (13.11) treatment combination.

4.2.4 Number of grains row^{-1}

Effect of different earthing up practices

On white maize, different earthing up practices had shown significant effect on the number of grains row^{-1} (Figure 13). According to the experimental results, the E_1 treatment had the highest number of grains row^{-1} of white maize (27.88), while the E_0 treatment had the lowest number of grains row^{-1} of white maize (25.88). Earthing up creates fine tilth with better aeration in the root zone, ensuring favorable conditions for root development. Furthermore, it provides anchorage for the lower whorls of adventitious roots above the soil level, which then function as absorbing roots. These conditions cause roots to absorb more water and nutrients from the soil. Earthing up also improves nutrient use efficiency by reducing losses due to volatilization, resulting in increased grain grains row^{-1} of cob. Similar result was observed by Pandey *et al.* (2001) who reported that highest values of yield attributes and highest grain yield (4080 kg ha^{-1}) was obtained in maize from the treatment Allachlor + Earthing up. Further, they reported that in terms of weed control earthing up treatment was most effective followed by hand weeding and paraquat application.

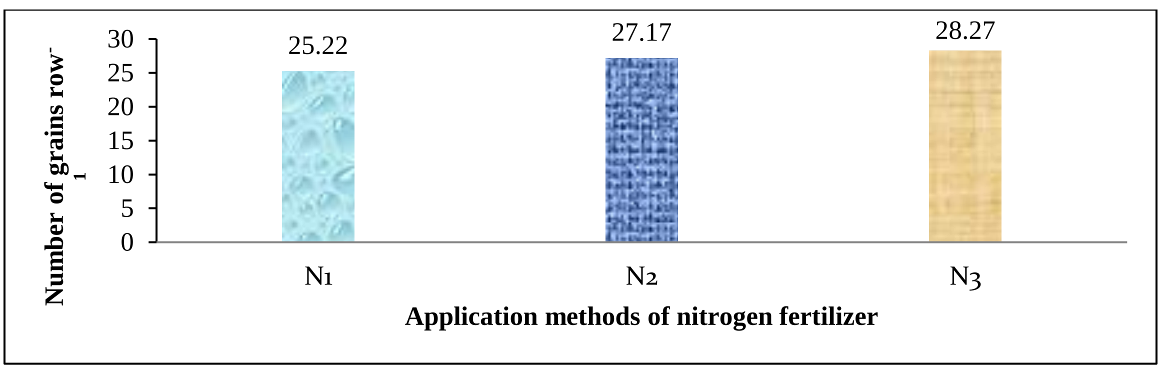


Here, E_0= No earthing up, E_1= Earthing up at 45 DAS.

Figure 13. Effect of different earthing up practices on the number of grains row^{-1} of white maize at harvest (LSD$_{(0.05)}$: 0.82).

Effect of application method of nitrogen fertilizer

The effect of nitrogen fertilizer application methods on the number of grains row^{-1} of white maize was found to be significant (Figure 14). The experimental results revealed that the N_3 treatment had the highest number of grains row^{-1} of white maize (28.27), while the N_1 treatment had the lowest number of grains row^{-1} of white maize (25.22). The result obtained from the present study was similar with the findings of Arun *et al*. (2014) who reported that the higher number of grains row^{-1} was observed in maize when 100 kg N/ha was applied as 3 splits doses i.e. basal, 25 and 45 DAS.



Here, N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS.

Figure 14. Effect of application methods of nitrogen fertilizer on the number of grains row^{-1} of white maize at harvest (LSD$_{(0.05)}$: 0.34).

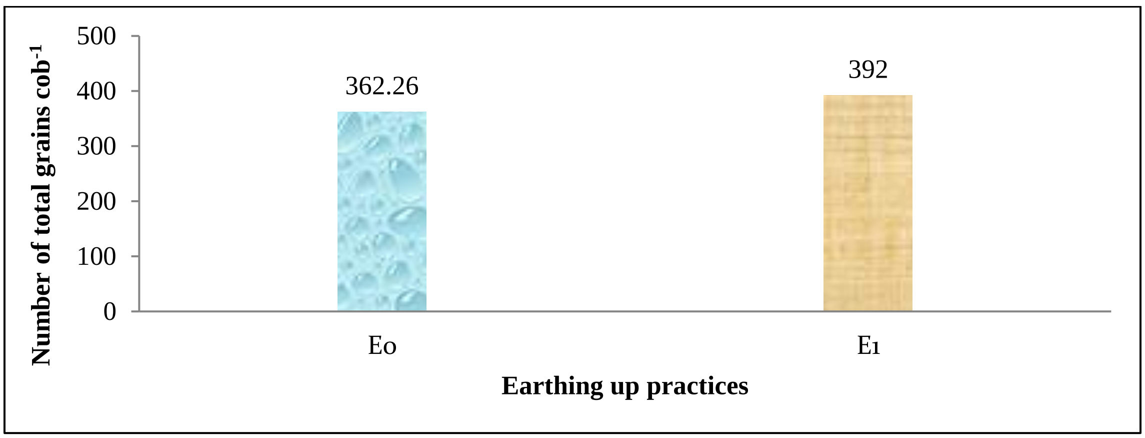
Combined effect of earthing up practices and application methods of nitrogen fertilizer

The combined effect of earthing up practices and nitrogen fertilizer application methods significantly influenced the number of grains row^{-1} of white maize at harvest (Table 5). The experimental results revealed that the E_1N_3 treatment combination had the highest number of grains row^{-1} (28.66) of white maize, which was statistically similar to the E_1N_2 (28.44) and E_0N_3 (27.87) treatment combination. While the E_0N_1 treatment combination had the lowest number of grains row^{-1} (23.89) of white maize.

4.2.5 Number of total grains cob^{-1}

Effect of different earthing up practices

The number of total grains cob^{-1} of white maize at harvest had significantly changed as a result of various earthing up practices (Figure 15). The results of the experiment showed that the E_1 treatment had the highest total number of white maize grains cob^{-1} (392.00), whereas the E_0 treatment had the lowest total number of white maize grains cob^{-1} (362.26).

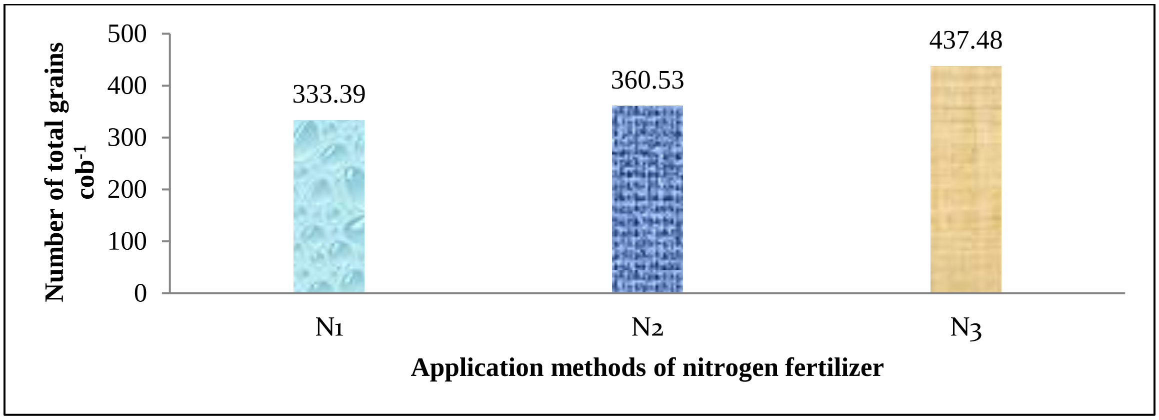


Here, E_0= No earthing up, E_1= Earthing up at 45 DAS.

Figure 15. Effect of different earthing up practices on the number of total grains cob^{-1} of white maize at harvest (LSD$_{(0.05)}$: 8.28).

Effect of application methods of nitrogen fertilizer

It was discovered that the methods used to apply nitrogen fertilizer had a significant impact on the number of total grains cob^{-1} of white maize grains at harvest (Figure 16). According to the experimental findings, the N_3 treatment had the highest number of total grains cob^{-1} of white maize (437.48), whereas the N_1 treatment produced the least number of total grains cob^{-1} of white maize at harvest.



Here, N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS.

Figure 16. Effect of application methods of nitrogen fertilizer on the number of total grains cob^{-1} of white maize at harvest ($LSD_{(0.05)}$: 14.38).

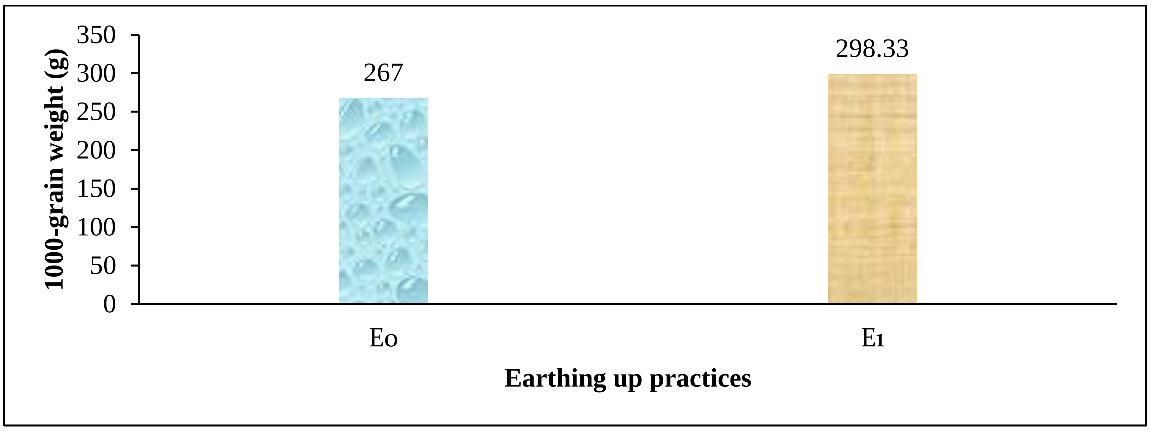
Combined effect of earthing up practices and application methods of nitrogen fertilizer

The number of total grains cob^{-1} of white maize at harvest was significantly impacted by the combined effects of earthing up practices and nitrogen fertilizer application methods (Table 5). According to the experimental findings, the E_1N_3 treatment combination had the highest number of total grains cob^{-1} of white maize (449.10) which was statistically similar with E_0N_3 (425.85) treatment combination. While the number of total grains cob^{-1} of white maize was found to be lowest (312.72) in the E_0N_1 treatment combination.

4.2.6 1000-grain weight (g)

Effect of different earthing up practices

The weight of 1000 grains of white maize had significantly varied as a result of the different earthing up practices (Figure 17). The experimental findings revealed that the E_1 treatment recorded the highest 1000 grain weight of white maize (298.33 g), while the lowest 1000 grain weight of white maize (267.00 g) was found to be E_0 treatment. This increase in grain weight may be attributed to the beneficial effects of earthing up and uniform application of top dressed fertilizers by the human labor.

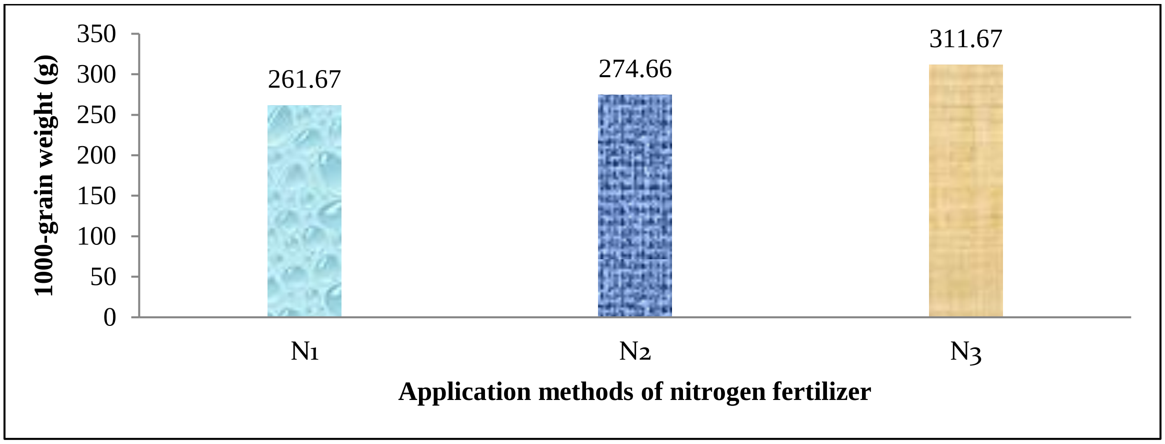


Here, E_0= No earthing up, E_1= Earthing up at 45 DAS.

Figure 17. Effect of different earthing up practices on the 1000-grain weight of white maize at harvest ($LSD_{(0.05)}$: 19.12).

Effect of application methods of nitrogen fertilizer

The methods of applying nitrogen fertilizer had shown significant impact on the 1000 grains of white maize (Figure 18). According to the experimental results, the N_3 treatment had the highest 1000 grains (311.67 g) of white maize. Nevertheless, the N_1 treatment had the lowest 1000 grains (261.67 g) of white maize which was statistically similar with N_2 (274.66 g) treatment. Split application of N can increase the availability of N to the maize plant, which can lead to increased growth and development. This can result in larger plants with more leaves, which can photosynthesize more efficiently and produce more carbohydrates. These carbohydrates can then be used to produce more grain, which will result in a higher 1000 grain weight. Nemati and Sharifi (2012) reported that three split of nitrogen fertilizer significantly influenced 1000 grains weight of maize as comparable to control treatment.



Here, N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS.

Figure 18. Effect of application methods of nitrogen fertilizer on the 1000-grain weight of white maize at harvest ($LSD_{(0.05)}$: 20.57).

Combined effect of earthing up practices and application methods of nitrogen fertilizer

The 1000 grains weight of white maize was significantly influenced by the combined effect of earthing up practices and application methods of nitrogen fertilizer (Table 5). According to the experimental results, the highest 1000 grains (331.67 g) of white maize was obtained with the E_1N_3 treatment combination. While the lowest 1000 grains (245.00 g) of white maize was obtained with the E_0N_1 treatment combination (245.00 g) which was statistically similar with E_0N_2 (264.33 g) treatment combination

Table 5. Combined effect of earthing up practices and application methods of nitrogen fertilizer on the number of rows cob^{-1}, grains row^{-1}, total grains cob^{-1} and 1000-grain weight (g) of white maize at harvest.

Treatment combinations	Number of rows cob^{-1}	Number of grains row^{-1}	No. of total grains cob^{-1}	1000-grain weight (g)
E_0N_1	13.09 b	23.89 c	312.72 c	245.00 c
E_0N_2	13.45 b	25.89 b	348.22 b	264.33 bc
E_0N_3	15.28 a	27.87 a	425.85 a	291.67 b
E_1N_1	13.33 b	26.56 b	354.04 b	278.33 b
E_1N_2	13.11 b	28.44 a	372.85 b	285.00 b
E_1N_3	15.67 a	28.66 a	449.10 a	331.67 a
$LSD_{(0.05)}$	0.76	0.78	26.74	29.29
CV(%)	5.84	4.52	4.87	5.47

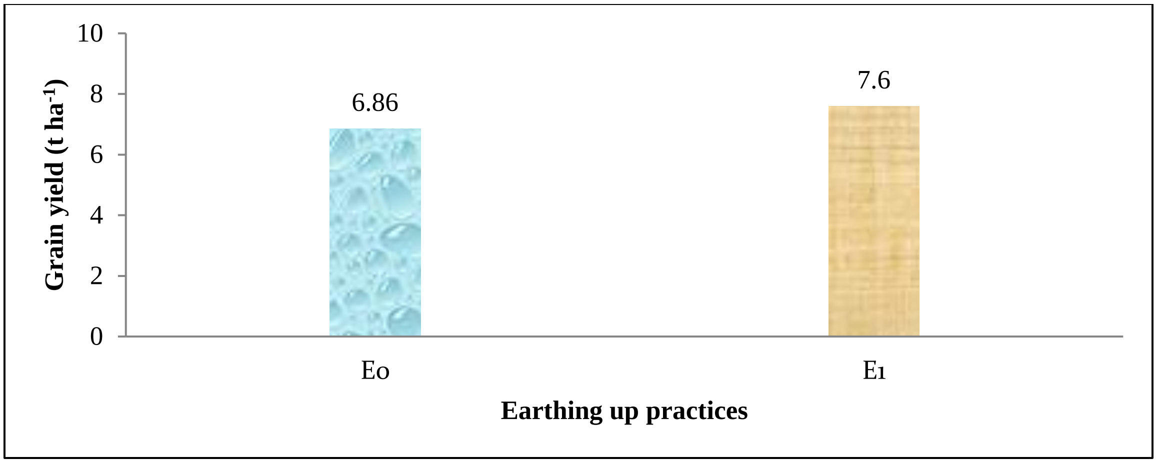
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, E_0= No earthing up, E_1= Earthing up at 45 DAS, N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS.

4.3 Yield characters

4.3.1 Grain yield (t ha^{-1})

Effect of different earthing up practices

The different earthing up practices had shown significant impact on the grain yield of white maize (Figure 19). The results of the experiment revealed that the E_1 treatment had the highest grain yield (7.60 t ha^{-1}). While the lowest grain yield (6.86 t ha^{-1}) of white maize was obtained in the E_0 treatments. This increase in grain yield is likely due to the beneficial effects of earthing up and uniform application of top dressed fertilizers by human labor. Similar result also observed by Ahmad and Chudhry (2008) who reported that flat sowing with earthing up resulted in maximum grain yield (5236 kg ha^{-1}). Pandey *et al.* (2001) reported from Almora, Uttarakhand that highest values of yield attributes and highest grain yield (4080 kg ha^{-1}) was obtained in maize from the treatment Allachlor + Earthing up.

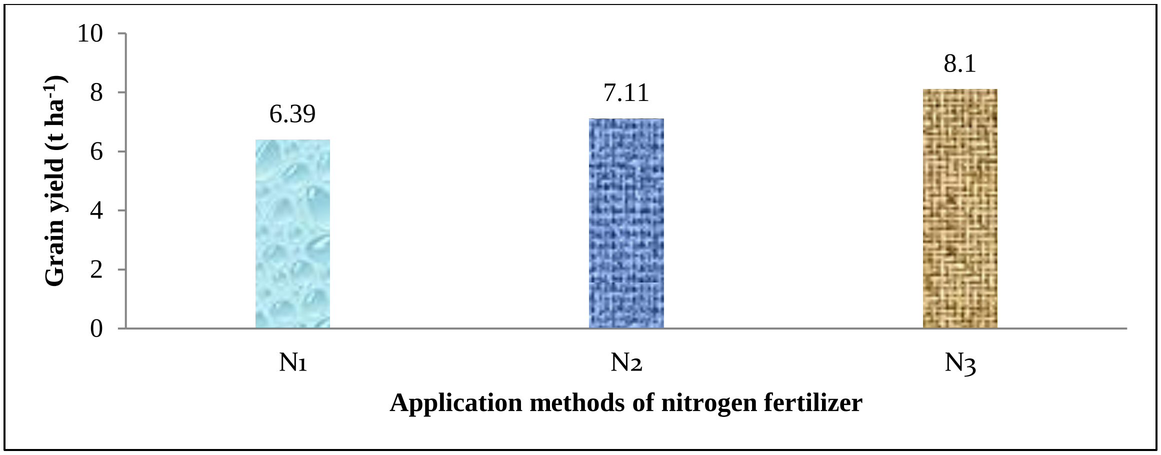


Here, E_0= No earthing up, E_1= Earthing up at 45 DAS.

Figure 19. Effect of different earthing up practices on the grain yield of white maize at harvest ($LSD_{(0.05)}$: 0.64).

Effect of application methods of nitrogen fertilizer

The application methods of nitrogen fertilizer had shown significant impact on white maize grain yield (Figure 20). According to the experimental findings, the N_3 treatment had the highest grain yield of white maize (8.10 t ha^{-1}). Nevertheless, the N_1 treatment produced the lowest highest grain yield of white maize (6.39 t ha^{-1}). Split application made nitrogen nutrients available to the plants when they were most needed, allowing the nutrients to be used more efficiently and resulting in healthy vegetative growth, increased yield contributing characteristics, and maximum production of white maize grain yield. The result was similar with the findings of Tadesse *et al.* (2013) who reported that application of 128 kg N ha^{-1} in two equal split 1/3 N at planting and 2/3 at knee height significantly ($p<0.05$) out-yielded the other split applications. Kaleem *et al*. (2012) reported that the split application of N showed a significant increase in both straw and grain yield (6%) over full basal N application.



Here, N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS.

Figure 20. Effect of application methods of nitrogen fertilizer on the grain yield of white maize at harvest (LSD$_{(0.05)}$: 0.42).

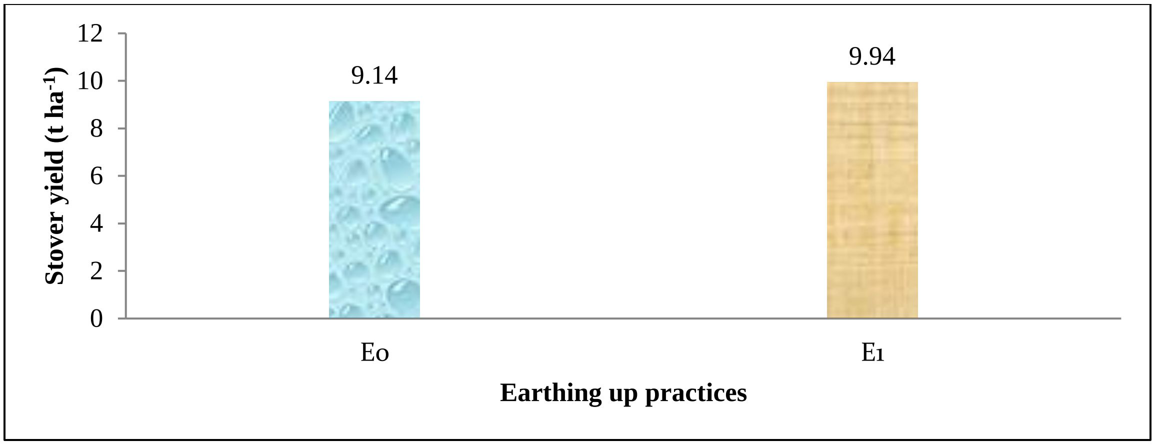
Combined effect of earthing up practices and application methods of nitrogen fertilizer

The combined effects of earthing up practices and application methods of nitrogen fertilizer, significantly influenced the grain yield of white maize (Table 6). According to the experimental findings, the E_1N_3 treatment combination had the highest grain yield of white maize (8.50 t ha^{-1}) which was statistically similar with E_0N_3 (7.87 t ha^{-1}) treatment combination. Whereas the lowest grain yield of white maize (5.82 t ha^{-1}) was recorded by the E_0N_1 treatment combination.

4.3.2 Stover yield (t ha^{-1})

Effect of different earthing up practices

Due to the effect of various earthing up practices, the stover yield of white maize was found to be varied significantly (Figure 21). The results of the experiment demonstrated that, the highest stover yield of white maize (9.94 t ha^{-1}) was observed in E_1 treatment, while the lowest stover yield of white maize (9.14 t ha^{-1}) was observed in E_0 treatment.

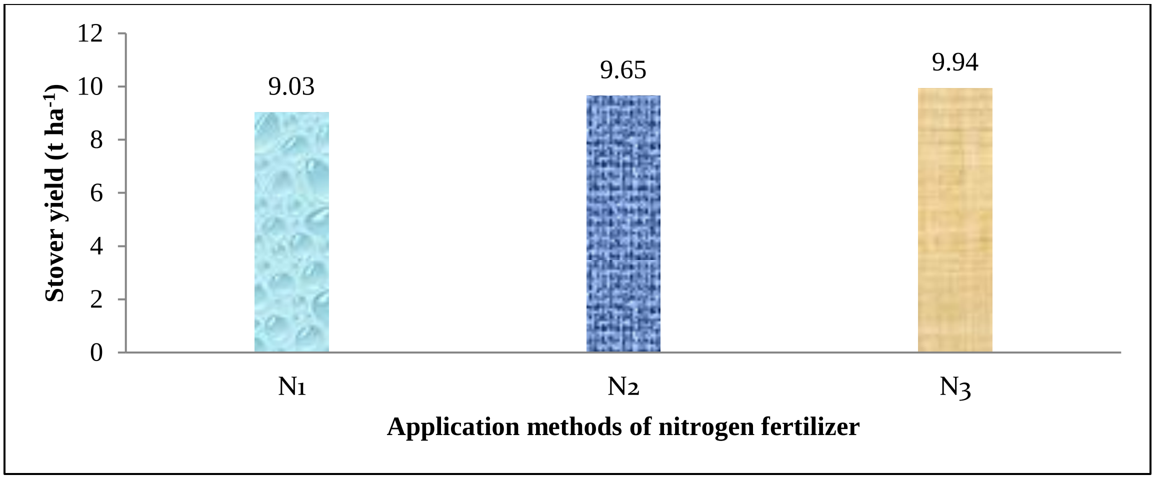


Here, E_0= No earthing up, E_1= Earthing up at 45 DAS.

Figure 21. Effect of different earthing up practices on the stover yield of white maize at harvest (LSD$_{(0.05)}$: 0.69).

Effect of application methods of nitrogen fertilizer

Nitrogen fertilizer application methods had shown significant effect on the white maize stover yield (Figure 22). According to the experimental results, the N_3 treatment recorded the highest stover yield of white maize (9.94 t ha^{-1}). Nonetheless, the N_1 treatment recorded the lowest stover yield of white maize (9.03 t ha^{-1}). The findings were similar to those of Kaleem *et al*. (2012) reported that the highest stover yield of maize was obtained from three split potassium applications and the lowest was obtained from basal nitrogen applications. Ogoke *et al.* (2003) reported that application of nitrogen in two equal splits (at planting and tasselling stage) gave higher stover yield as compared to when nitrogen was applied first at three weeks after planting and second at tasselling stage in a humid tropical environment of Nigeria.



Here, N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS.

Figure 22. Effect of application methods of nitrogen fertilizer on the stover yield of white maize at harvest (LSD$_{(0.05)}$: 0.27).

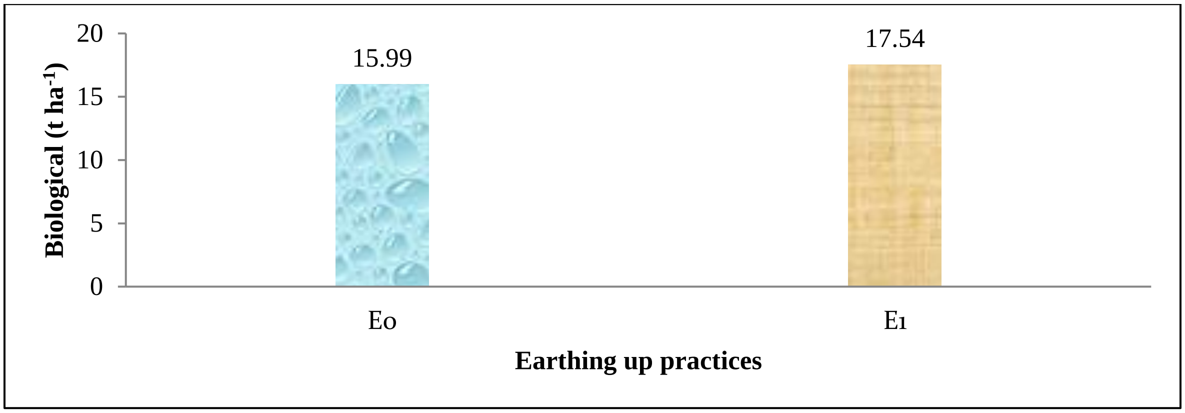
Combined effect of earthing up practices and application methods of nitrogen fertilizer

Stover yield of white maize was significantly influenced by earthing up practices and application methods of nitrogen fertilizer (Table 6). The E_1N_3 combination treatment produced the highest stover yield of white maize (10.10 t ha^{-1}) which was statistically similar with all others treatment combination except E_0N_1 combination treatment. While the E_0N_1 combination treatment produced the lowest stover yield of white maize (8.22 t ha^{-1}).

4.3.3 Biological (t ha^{-1})

Effect of different earthing up practices

Different earthing up practices had shown significant effect on the biological yield of white maize (Figure 23). The E_1 treatment produced the highest biological yield (17.54 t ha^{-1}) of white maize in this experiment. While the E_0 treatments had the lowest biological yield of white maize (15.99 t ha^{-1}). Higher biological yield results from increased grain and stover yield. This could be due to the fact that a plant with earthing practice receives more porous soil than a flat planted crop, which promotes better plant growth and development. The result was similar with the findings of Thakur *et al.* (2003) who revealed that maize plant recorded significantly higher grain, straw yieldand biological yield on vertisols of Madhya Pradesh, when it was provided with earthing up at 25 days after sowing as compared to the treatments in which earthing up was not done and plants were sown as flat planting.

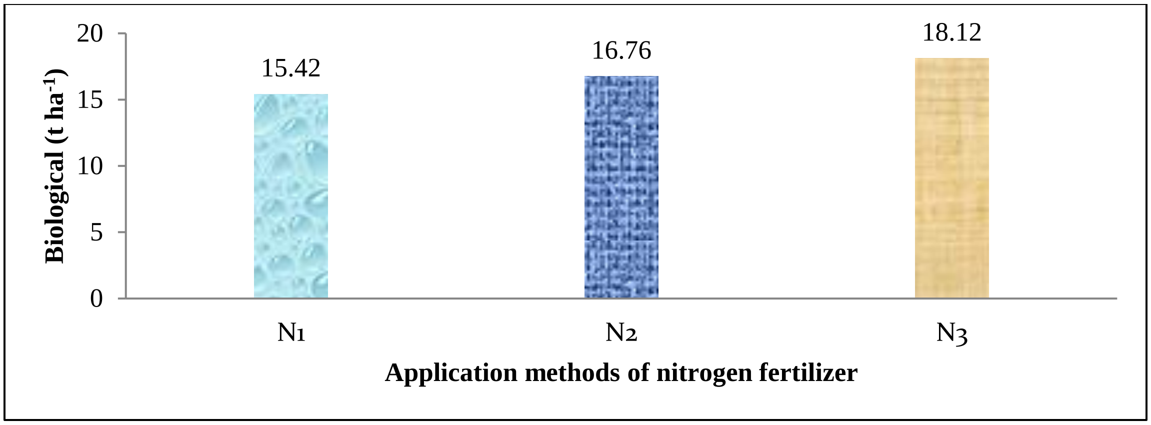


Here, E_0= No earthing up, E_1= Earthing up at 45 DAS.

Figure 23. Effect of different earthing up practices on the biological yield of white maize at harvest ($LSD_{(0.05)}$: 1.34).

Effect of application methods of nitrogen fertilizer

Different nitrogen application methods has shown significant effect on biological yield of white maize (Figure 24). According to the experimental findings, the highest biological yield (18.12 t ha^{-1}) of white maize was recorded in the N_3 treatment, while the lowest biological yield (15.42 t ha^{-1}) was recorded in the N_1 treatment. The result was similar with the findings of Mburu *et al.* (2011) who observed significant increase in maize biological yield when nitrogen was applied in splits.



Here, N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS.

Figure 24. Effect of application methods of nitrogen fertilizer on the biological yield of white maize at harvest ($LSD_{(0.05)}$: 0.67).

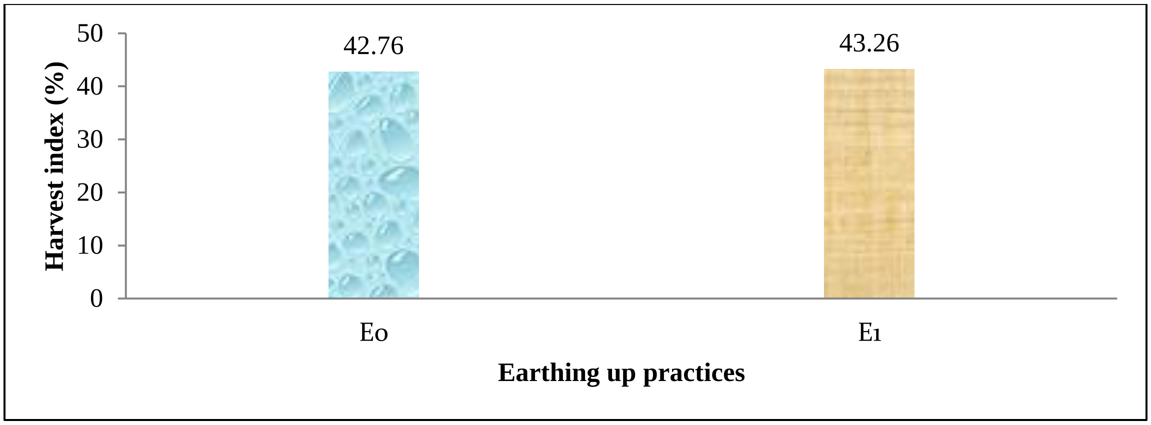
Combined effect of earthing up practices and application methods of nitrogen fertilizer

Different earthing up practices and nitrogen fertilizer application methods had shown significant impact on biological yield of white maize (Table 6). The E_1N_3 combination treatment produced the highest biological yield (18.60 t ha^{-1}) of white maize which was statistically similar with E_0N_3 (17.64 t ha^{-1}) combination treatment. While the E_0N_1 combination treatment produced the lowest biological yield (14.04 t ha^{-1}) of white maize.

4.3.4 Harvest index (%)

Effect of different earthing up practices

The various earthing up practices had shown significant effect on the harvest index of white maize (Figure 25). According to the results of the experiment, the E_1 treatment had the highest harvest index (43.26 %) of white maize. While the E_0 treatments had the lowest harvest index (42.76 %) of white maize.

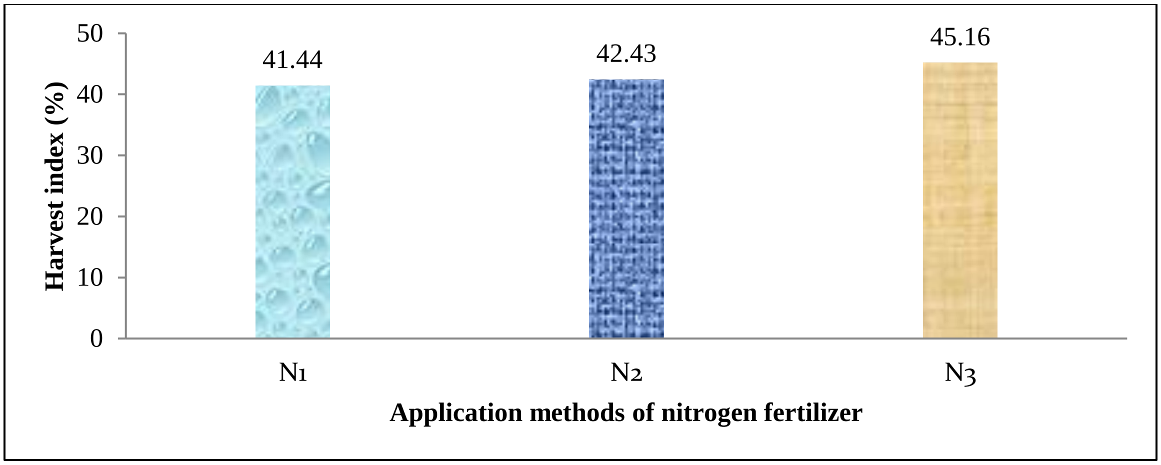


Here, E_0= No earthing up, E_1= Earthing up at 45 DAS.

Figure 25. Effect of different earthing up practices on the harvest index of white maize at harvest ($LSD_{(0.05)}$: 0.31).

Effect of application methods of nitrogen fertilizer

The application methods of nitrogen fertilizer had shown significant impact on the harvest index of white maize (Figure 26). According to the experimental findings, the N_3 treatment had the highest harvest index of white maize (45.16 %). Nevertheless, the N_1 treatment had the least harvest index of white maize (41.44 %). Scientific fertilizer application is an important tool for increasing crop growth while also protecting the environment and ensuring agricultural sustainability. Plant fresh and dry weight are important measures of growth vigor because they reflect plant biomass accumulation to some extent. With split nitrogen fertilizer application increased nutrients availability in the root zone, resulting in greater nutrient uptake by the plant and higher grain and biological yield, which influences crop harvest index. The result was similar with the findings of Hassan *et al*. (2010) who reported that split application of nitrogen significantly influenced harvest index of maize.



Here, N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS.

Figure 26. Effect of application methods of nitrogen fertilizer on the harvest index of white maize at harvest ($LSD_{(0.05)}$: 0.64).

Combined effect of earthing up practices and application methods of nitrogen fertilizer

The combined effect of earthing up practices and application methods of nitrogen fertilizer had shown significant effect on white maize harvest index (Table 6). Experimental results, revealed that the E_1N_3 treatment combination had the highest harvest index of white maize (45.70 %), while the E_0N_1 treatment combination had the lowest harvest index of white maize (41.45 %).

Table 6. Combined effect of earthing up practices and application methods of nitrogen fertilizer on the grain, stover, biological yield and harvest index of white maize

Treatment combinations	Grain yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Biological ($t\ ha^{-1}$)	Harvest index (%)
E_0N_1	5.82 d	8.22 b	14.04 d	41.45 d
E_0N_2	6.88 c	9.42 a	16.30 c	42.21 cd
E_0N_3	7.87 ab	9.77 a	17.64 ab	44.61 b
E_1N_1	6.96 c	9.84 a	16.80 bc	41.43 d
E_1N_2	7.34 bc	9.87 a	17.21 bc	42.65 c
E_1N_3	8.50 a	10.10 a	18.60 a	45.70 a
$LSD_{(0.05)}$	0.77	0.73	1.48	0.79
CV(%)	5.46	4.60	4.00	2.13

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, E_0= No earthing up, E_1= Earthing up at 45 DAS, N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS.

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka during the period from October-2021 to February-2022 in Rabi season, to study the growth and yield of white maize as influenced by earthing up practices and application methods of nitrogen fertilizer. The experiment consisted of two factors, and followed split plot design with three replications. Factor A: Earthing up practices (2) *viz*: E_0= No earthing up E_1= Earthing up at 45 DAS and Factor B: Application method of nitrogen fertilizer (3) *viz*: N_1= Side dressing at 85 DAS, N_2= Two splits of N-50% at 45 DAS + 50% at 85 DAS and N_3 = Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS. The analysis of various parameter data revealed significant differences in maize growth and yield, as a result of earthing up practices and different application method of nitrogen fertilizer and their combination treatment.

In case of different earthing up practices on maize, the highest plant height (25.81,78.24, 136.83 and 150.63 cm) at 30, 60, 90 DAS and at harvest, respectively, number of leaves plant^{-1} (5.72, 10.69, 12.51 and 13.09) at 30, 60, 90 DAS and at harvest, respectively, dry matter weight plant^{-1} (233.31 g), cob length (21.50 cm), cob circumference (18.19 cm), rows cob^{-1} (14.04), grains row^{-1} (27.88), total grains cob^{-1} (392.00), 1000 grain weight (298.33 g), grain yield (7.60 t ha^{-1}), stover yield (9.94 t ha^{-1}), biological yield (17.54 t ha^{-1}) and harvest index (43.26 %) were observed in E_1 treatment. While the lowest plant height (25.20, 67.77, 120.93 and 148.57 cm) at 30, 60, 90 DAS and at harvest, respectively, number of leaves plant^{-1} (5.64, 9.76, 11.77 and 11.91) at 30, 60, 90 DAS and at harvest, respectively, dry matter weight plant^{-1} (204.42 g), cob length (20.22 cm), cob circumference (17.77 cm), rows cob^{-1} (13.94), grains row^{-1} (25.88), total grains cob^{-1} (362.26), 1000 grain weight (267.00 g), grain yield (6.86 t ha^{-1}), stover yield (9.14 t ha^{-1}), biological yield (15.99 t ha^{-1}) harvest index (42.76 %) were observed in E_0 treatment.

Growth and yield of maize significantly influenced due to application method of nitrogen fertilizer. According to the experimental findings, the highest plant height (27.85, 89.80, 144.70 and 164.45 cm) at 30, 60, 90 DAS and at harvest, respectively, number of leaves plant^{-1} (5.72, 10.69, 12.51 and 13.09) at 30, 60, 90 DAS and at harvest, respectively, dry matter weight plant^{-1} (257.10 g), cob length (21.99 cm), cob circumference (18.66 cm), rows cob^{-1} (15.47), grains row^{-1} (28.27), total grains cob^{-1} (437.48), 1000 grains (311.67 g), grain yield (8.10 t ha^{-1}), stover yield (9.94 t ha^{-1}), biological yield (18.12 t ha^{-1}) and harvest index (45.16 %) were observed in N_3 treatment. While the lowest plant height of white maize (21.75, 58.60, 111.75 and 140.60 cm) at 30, 60, 90 DAS and at harvest, respectively, number of leaves plant^{-1} (5.64, 9.76, 11.77 and 11.91) at 30, 60, 90 DAS and at harvest, respectively, dry matter weight plant^{-1} (166.41 g), cob length (19.16 cm), cob circumference (16.96 cm), rows cob^{-1} (13.21), grains row^{-1} (25.22), total grains cob^{-1} (333.39), 1000 grains (261.67 g), grain yield (6.39 t ha^{-1}), stover yield (9.03 t ha^{-1}), biological yield (15.42 t ha^{-1}) and harvest index (41.44 %) were observed in N_1 treatment.

In case of combination, E_1N_3 treatment combination gave the highest plant height (28.30, 92.70, 153.70 and 168.80 cm) at 30, 60, 90 DAS and at harvest, respectively, number of leaves number plant^{-1} (6.07, 11.20, 13.13 and 14.33) at 30, 60, 90 DAS and at harvest, respectively, dry matter weight plant^{-1} (319.53 g), cob length (22.66 cm), cob circumference (19.16 cm), rows cob^{-1} (15.67), grains row^{-1} (28.66), total grains cob^{-1} (449.10), 1000 grains (331.67 g), grain yield (8.50 t ha^{-1}), stover yield (10.10 t ha^{-1}), biological yield (18.60 t ha^{-1}) and harvest index (45.70 %). While corresponding lowest value were found in E_0N_1 treatment combination.

Conclusion

Based on the above findings, experimental results revealed that different earthing up practices, application method of nitrogen fertilizer and their combination treatment significantly influenced the growth and yield of white maize. However, considering above all facts, it may be concluded that earthing up at 45 DAS (E_1), Three splits of N-33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS (N_3), and their combination (E_1N_3) seems promising for increasing growth and yield of maize than compared to other combination treatment. Therefore, it was suggested that cultivation of white maize through applying earthing up practice at 45 DAS along with three splits of Nitrogen fertilizer @ 33% at 45 DAS +33% at 65 DAS + 33% at 85 DAS would help to influenced plant growth and increase its ability to enhanced better yield production of white maize.

Recommendations

Considering the results of the experiment, further studies in the following areas are suggested:

- ✓ Different agronomic practices and different split doses of nitrogen fertilizer may be taken for further experiments to get more accurate result.
- ✓ Studies of similar nature could be carried out in different agro-ecological zones (AEZ) in different seasons of Bangladesh for the evaluation of zonal adaptability

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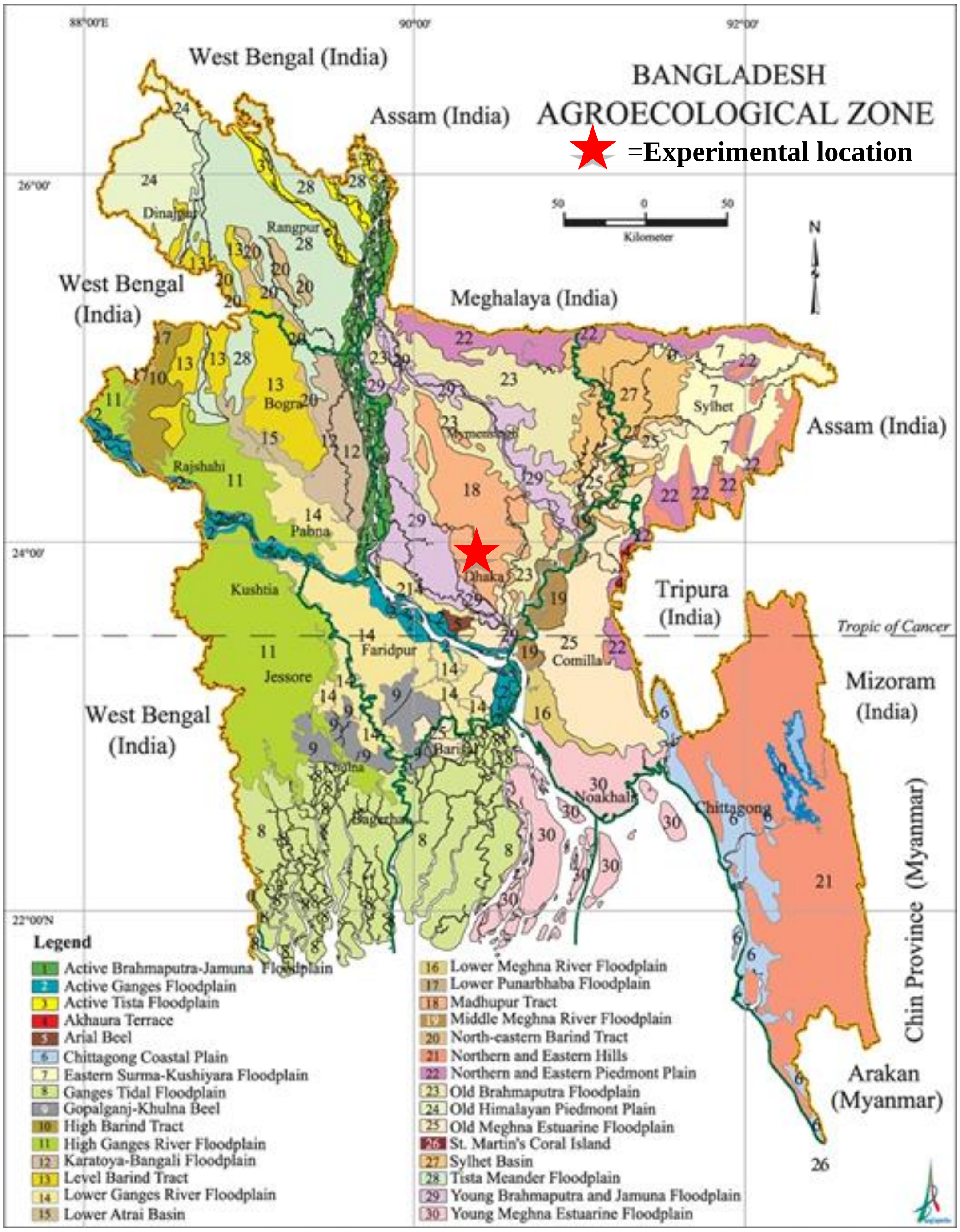
APPENDICES

Appendix I. Map showing the experimental location under study



Appendix II. Soil characteristics of the experimental field

A. Morphological features of the experimental field

Morphological features	Characteristics
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Location	Sher-e-Bangla Agricultural University Agronomy research field, Dhaka
Soil series	Tejgaon
Topography	Fairly leveled

B. The initial physical and chemical characteristics of soil of the experimental site (0- 15 cm depth)

Physical characteristics	
Constituents	**Percent**
Clay	29 %
Sand	26 %
Silt	45 %
Textural class	Silty clay
Chemical characteristics	
Soil characteristics	**Value**
Available P (ppm)	20.54
Exchangeable K (mg/100 g soil)	0.10
Organic carbon (%)	0.45
Organic matter (%)	0.78
pH	5.6
Total nitrogen (%)	0.03

Sourse: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka.

Appendix III. Monthly meteorological information during the period from October 2021 to February, 2022.

Year	**Month**	**Air temperature (^{0}C)**		**Relative humidity (%)**	**Average rainfall (mm)**
		Maximum	**Minimum**		
2021	October	31.2	23.9	76	52 mm
	November	29.6	19.8	53	00 mm
	December	28.8	19.1	47	00 mm
2022	January	25.5	13.1	41	00 mm
	February	25.9	14	34	7.7 m

Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix IV. Analysis of variance of the data on the plant height of white maize at different days after sowing

Source	**DF**	Mean square of plant height at			
		30	60	90	At harvest
Replication (R)	2	1.0556	20.17	1.50	80.67
Earthing up (E)	1	1.6806^{Ns}	493.92*	1137.64*	19.22^{Ns}
Error	2	0.3889	4.17	48.17	54.00
Nitrogen (N)	2	64.7287*	1485.86*	1636.35*	1007.23*
E×N	2	0.5756*	25.07*	6.04*	274.60*
Error	8	0.7222	12.17	24.83	67.33

*: Significant at 0.05 level of probability

^{Ns}: Non significant

Appendix V. Analysis of variance of the data on the number of leaves plnat^{-1} of white maize at different days after sowing

Source	**DF**	Mean square of number of leaves plnat^{-1} at			
		30	60	90	At harvest
Replication (R)	2	0.00282	0.12615	0.00427	0.0058
Earthing up (E)	1	0.02880^{Ns}	3.89205*	2.48645*	6.2305*
Error	2	0.00282	0.12615	0.00167	0.0058
Nitrogen (N)	2	1.16540*	9.54980*	2.87885*	12.6200*
E×N	2	0.00780*	1.14000*	0.14345*	0.5558*
Error	8	0.00132	0.09815	0.00297	0.0058

*: Significant at 0.05 level of probability

^{Ns}: Non significant

Appendix VI. Analysis of variance of the data on the dry matter weight plant^{-1}, cob length, cob circumference of white maize

Source	**DF**	Dry matter weight plant^{-1}	Cob length	Cob circumference
Replication (R)	2	66.7	0.3267	0.32667
Earthing up (E)	1	3755.8*	7.4498*	0.80222 ^{Ns}
Error	2	66.7	0.3267	0.06000
Nitrogen (N)	2	13249.8*	13.4924*	4.85524*
E×N	2	41.5*	0.8124*	0.43357*
Error	8	66.7	0.2617	0.19333

*: Significant at 0.05 level of probability
^{Ns}: Non significant

Appendix VII. Analysis of variance of the data on the number of rows cob^{-1}, number of grains row^{-1}, total number of grains cob and 1000-grain weight of maize

Source	**DF**	Number of rows cob^{-1}	Number of grains row^{-1}	Total number of grains cob	1000-grain weight
Replication (R)	2	0.66667	0.1667	16.7	88.89
Earthing up (E)	1	0.04205 ^{Ns}	18.0601*	3978.3*	4417.69*
Error	2	0.66667	0.1667	16.7	88.89
Nitrogen (N)	2	9.95315*	14.2152*	17492.1*	4038.66*
E×N	2	0.22295*	1.6616*	152.0*	144.59*
Error	8	0.16667	0.1667	116.7	238.89

*: Significant at 0.05 level of probability
^{Ns}: Non significant

Appendix VIII. Analysis of variance of the data on the grain yield, stover, biological yield and harvest index of maize

Source	**DF**	Grain yield	Stover yield	Biological yield	Harvest index
Replication (R)	2	38.4029	66.8468	206.583	693.644
Earthing up (E)	1	2.4864*	2.8800*	10.718*	1.140*
Error	2	0.1015	0.1176	0.438	0.024
Nitrogen (N)	2	4.8961*	1.2814*	10.935*	22.207*
E×N	2	0.1879*	0.7619*	1.666*	0.467*
Error	8	0.1038	0.0417	0.257	0.236

*: Significant at 0.05 level of probability

Ns: Non significant

PLATES

Plate 1. Layout of the experimental field

Plate 2. Vegetative stage of white maize

Plate 3. Tassel initiation of white maize

Plate 4. Plant observing in the experimental field