EFFECTS OF UREA AND COW DUNG ON THE GROWTH AND YIELD OF GREEN AMARANTH

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CERTIFICATE

This is to certify that the thesis entitled "EFFECTS OF UREA AND COW DUNG ON THE GROWTH AND YIELD OF GREEN AMARANTH" submitted to the DEPARTMENT OF AGRICULTURAL CHEMISTRY, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (M.S.) in AGRICULTURAL CHEMISTRY, embodies the results of a piece of *bonafide* research work carried out by TAHMINA ZAMAN TONOYA, Registration. No. 08-02718, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma in any other institution.

I further certify that any help or sources of information received during the course of this investigation have duly been acknowledged.

Dated:
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DEDICATED TO MY BELOVED PARENTS FOR WHOM I EXIST. WHATEVER GOOD I HAVE, THAT'S FOR YOU; AND WHATEVER BAD, THAT'S ONLY MINE.

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ABSTRACT

The effect of different levels of nitrogen fertilizer applied as urea in combination with cow dung (CD) on the growth and yield of green amaranth cv. BARI Data-1 was investigated at Sher-e-Bangla Agricultural University Farm during the period from April to May, 2014. The experiment was consisted of four levels of nitrogen ($N_0 = 0$, $N_1 = 75$, $N_2 = 100$ and $N_3 = 125$ kg N ha^{-1}) and four levels of cow dung ($C_0 = 0$, $C_1 = 2.5$, $C_2 = 5$ and $C_3 = 7.5$ t CD ha^{-1}). The experiment was laid out in a randomized complete block design with three replications. A statistically significant variation was recorded in respect of all characteristics of green amaranth. The results showed that nitrogen, cow dung and their interaction significantly influenced most of the growth and yield contributing characteristics such as plant height, number of leaves, stem diameter, leaf greenness, fresh and dry weight of leaf, stem and root along with the individual yield of leaf and stem or summation of them as green yield. All parameters studied in this experiment were increased with the increasing nitrogen levels *i.e.* 125 kg N ha^{-1}, gave the highest which showed statistically similar with 100 kg N ha^{-1} in case of final plant height, number of leaves, stem diameter and stem-leaf ratio. The growth and yield contributing parameters were increased with the increasing cow dung levels up to 5 t ha^{-1}. The highest green yield (69.74 t ha^{-1}) were obtained from the interaction of N_3C_1 (125 kg N ha^{-1} and 2.5 t CD ha^{-1}) treatment which is statistically similar with N_2C_2 (100 kg N ha^{-1} and 5 t CD ha^{-1}) in respect of highest plant height, maximum number of leaves plant^{-1} and widest stem diameter. The N_0C_0 showed the lowest values in case of all parameters. Therefore 100 kg N ha^{-1} were compatible to 5 t CD ha^{-1} for better as well as eco-friendly production of green amaranth.

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LIST OF ACRONYMS

AEZ	Agro Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
CD	Cow dung
C.V.	Coefficient of Variation
cv.	Cultivar
DAS	Days after sowing
E	East
et al.	*et alibi* (and others)
etc.	*et cetra* (and so on)
FAO	Food and Agriculture Organization
i.e.	id est (that is)
LSD	Least significant difference
N	North, Nitrogen
%	Percentage
^0C	Degree Celsius
mm	Millimeter
cm	Centimeter
g	Gram
ha	Hectare
kg	Kilogram
m	Meter
t	ton

Chapter I
Introduction

CHAPTER I

INTRODUCTION

Green amaranth (*Amaranthus viridus* L.) belongs to the genus *Amaranthus* and the family Amaranthaceae which is collectively known as amaranths. It is a cosmopolitan genus of herbs. But green amaranth or stem amaranth which also known as *danta* in bangla is commonly used as leafy and stem vegetable. It is mainly grown in summer and rainy season. It is an important popular vegetable in Bangladesh, because of its cheapest price, quick growing character and higher yield potential (Hossain, 1996). It is widely grown as a green vegetable in tropical and subtropical region of Asia, Africa and Central America (Hardwood, 1980).

Green amaranth is fairly rich in vitamin-A, ascorbic acid and fibers. It has an appreciable amount of iron, calcium, phosphorus, riboflavin, thiamine and niacin (Thompson and Kelly, 1988). It also contains about 43 calorie per 100g of edible portion which is higher than that of any other common vegetables except potato and taro (Chowdhury, 1967). Its wider environmental adaptability, higher nutritive value, good taste, less risk to crop failure and various biotic and abiotic factors indicate that there is enough scope for its promotional cultivation. It can be harvested after 30 days after sowing. Stem amaranth is considered as a potential upcoming subsidiary food crop for future (Teutonico and Knorr, 1985). It is also considered to be the cheapest vegetable in the market and it could be rigidly described as a poor man's vegetable in Bangladesh (Shanmugavelu, 1989).

Food scarcity has been and will remain a major concern for Bangladesh as population growth is 1.34% (BBS, 2013). Increased production of vegetable is important for balanced and healthy food intake. Total vegetable production in Bangladesh is about 1879.83 thousand tons per year of which 61.9% is produced in Rabi and 38.09% is in Kharif season (BBS, 2010). It shows that maximum vegetable production is concentrated during the months of November and April. Thus a serious scarcity of vegetables creates from May to September and the price becomes high. So malnutrition is acute during late summer in Bangladesh. Amaranth can be cultivated as the year round crop. Beside these, this crop proved to be best fitting in cropping system as a short duration crop. As the soil type and weather are suitable, stem amaranth can play an important role to minimize the scarcity of vegetable during lean period (Hossain, 1996; Talukder, 1999). Thus green amaranth ultimately plays a vital role in taking balanced food and helps to improve farmers' socio-economic condition.

Green amaranth is being cultivated in an area of 26,338 acres and 69667 tons that is increasing day by day due to high yield, easy cultivation process with nutritional value (BBS, 2013). The average yield of stem amaranth is only 2.64 ton acres^{-1} in Bangladesh, which is much lower as compared to other amaranth growing countries. For attaining considerable production and quality yield for any crop it is necessary to proper management including ensuring the availability of essential nutrient.

Fertilizer plays a vital role for proper growth and development of stem amaranth. Fertilizer application in appropriate time, appropriate dose and proper method is the prerequisite of amaranth cultivation (Islam, 2003). It grows well in a fertile, clay loam soil because it requires considerable amounts of nutrients to sustain rapid growth in short time. Stem amaranth responds greatly to major essential elements like N, P and K in respect of its growth and yield (Mital, 1975; Singh et al., 1976; Thompson and Kelly, 1988). Its production can be increased by adopting improved cultural practices. But most of the amaranth growers cultivate this crop in fallow land without following any management practices or fertilizer.

In Bangladesh, specially the nitrogenous fertilizer is the most critical input for increasing crop production and had been recognized as the central element for agricultural development (Monira, 2007). A large amount of nitrogen is required for leaf and stem growth of vegetables (Opena *et al.,* 1988). It plays a vital constituent of protein, nucleic acid and chlorophyll and progressively increases the marketable yield (Obreza and Vavrina, 1993). It is also the most different element to manage in a fertilization system such that an adequate, but not excessive amount of nitrogen is available during the entire growing season (Anon., 1992). Urea is the most commonly used nitrogenous fertilizer in Bangladesh. Generally, it is applied as basal and as top dressed at different growth stages for vegetable cultivation. It contains about 46% nitrogen. But excessive application of urea is not only uneconomical, it also induces different physiological disorder, causes health hazards, creates problem to the environment including the pollution of soil, air and water along with the increase of production cost. So an adequate supply of nitrogen is essential for vegetative growth, and desirable yield (Yoshizawa and Roan, 1981).

Organic farming is one of the most important factors of crop production as well as to harvest high yield. Organic manure may play a vital role to improve soil fertility as well as supply of primary, secondary and micronutrients for crops. It also helps to maximize soil organic matter and water holding capacity of soil, minimize the soil temperature and develop the favorable soil structure (Monira *et al.*, 2007).

Continuous use of chemical fertilizers accelerates the depletion of organic matters from soil. Most of the soils of Bangladesh have less than 1.5% and in some cases less than 1% organic matter (Zaman and Rahman, 1986). Organic manure increases the nutrient availability and reduces the chemical fertilizer cost. These facts suggest that there is an ample scope to increase stem amaranth yield in per unit area with appropriate use of organic nitrogen as organic manures exert a major role on crop production (Gaur *et al.*, 1984).

Further organic manure like cow dung is a good source of plant nutrients (Solaiman and Rabbani, 2006) and cow dung and poultry manure could be beneficially applied in agronomic and horticultural crop production (Noor *et al.*, 2001; Rahman *et al.*, 2005). As the practice of animal husbandry is common in the rural area of Bangladesh, cow dung can easily be found and applied in the field. It encompasses profitable vegetable yield and unacceptable loss to the soil environment. So application of cow dung is affordable and eco-friendly.

Recently organic farming including cow dung related researches are being encouraging to avoid pollution from agrochemicals (Belay *et al.*, 2001). The principal aims of using these as expressed in the recent studies are to produce crops with high nutritional qualities, to maintain and increase long term soil fertility and to minimize use of agrochemicals to avoid pollution arise from their uses. There is no denying of the fact that regular use of cow dung has a remarkable effect in improving the physio-chemical properties of the soil and ultimately the soil health but only as a supplement rather than as a substitute for fertilizers (Halvin *et al.*, 2003).

There is a great possibility of increasing amaranth yield per unit area with the appropriate use of urea fertilizer as nitrogen source and cow dung in Bangladesh. The balanced use of urea fertilizer and cow dung enhances the growth and development of green amaranth as well as ensuring the availability of other essential nutrients for the plant.

Information on the use of appropriate levels of urea along with cow dung with particular reference to green amaranth cultivation is lacking in general. In this aspect, the present study, therefore, is undertaken to investigate the effect of urea fertilizer and cow dung on green amaranth with the following objectives:

a) To examine the single effect of different levels of urea and cow dung application on the growth and yield of BARI Data-1.
b) To study the interaction effect of different levels of nitrogen fertilizer and cow dung application on growth and yield of green amaranth.
c) To quantify the suitable rate of urea fertilizer and cow dung for its cultivation.

Chapter II
Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Green amaranth or stem amaranth is one of the important summer vegetables in Bangladesh as well as in many other countries of the world. The crop has received less concentration of the researchers because normally it grows with less care or management practices. For that a very few studies on growth, yield and development of amaranth have been carried out in our country. The research work so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important research findings related to nitrogen fertilizer and cow dung so far available at home and abroad on this crop have been reviewed in this chapter under the following headings:

2.1 EFFECT OF UREA ON GROWTH AND YIELD

Green amaranth cultivar was supplied with 0, 30, 60 and 90 kg N ha^{-1} in a field experiment conducted by Rathore *et al.* (2004) in Rajasthan, India during the winter seasons of 1997-1998 and 1998-1999 to identify the optimum doses. As much as 90 kg ha^{-1} N fertilizer gave significantly higher yield, better growth and higher values for *yield components. Application of N enhanced the growth and yield attributes* significantly, whereas harvest index remained unaffected.

Islam (2003) reported that fertilizer doses at the rate of 200, 100 and 200 kg ha^{-1} of urea, triple super phosphate and muriate of potash respectively and maintaining other agricultural practices properly the average yield of amaranth could be raised up to 45 to 50 t ha^{-1}.

Three field experiments were conducted at the Taiwan Agricultural Research Institute experimental farm by Yung *et al.* (2003) to evaluate the growth response of amaranth at different nitrogen fertilizer rates during the 2001-2002 growing season. Data on the total leaf chlorophyll, aboveground nitrogen and chlorophyll meter readings from leaves were collected at harvest. Regression analysis indicated positive linear correlation between total leaf chlorophyll and chlorophyll meter readings and between aboveground nitrogen and total leaf chlorophyll. It suggests that chlorophyll meter is a suitable tool for the assessment of chlorophyll and nitrogen status in amaranth plants.

Ayodele *et al.* (2002) conducted a field experiment to evaluate the effect of N fertilizer @ 0, 50, 100 and 200 kg ha^{-1} on growth and yield of amaranth, plant height, number of leaves produced, fresh and dry weights of plant parts increased with increased nitrogenous fertilizer rate. Application of fertilizer at 200 kg N ha^{-1} increased leaf production upto 75%, on the other hand yield increased up to 114% with the application of 200 kg N ha^{-1}. The unfertilized plants also had yellowish green coloration compared to the brighter green color observed in fertilized plants.

Thapa and Maity (2002) carried out a field experiment in the sandy loam of West Bengal, India during the summer seasons of 1998 and 1999 to study the effect of different levels of N @ 50, 100 and 150 kg ha^{-1} on the growth and yield of *Amaranthus* sp. cv. local. The response in terms of growth components such as plant height, number of leaves and number of branches, leaf area index, yield and dry matter production was highest at the highest nutrient levels. The highest yields of 100.75, 101.5 were obtained from treatments with N @ 150 kg ha^{-1}.

Seeds of amaranth (*Amaranthus* spp.) cultivated under 8 N levels (0, 50, 100, 150, 200, 300, 350 and 400 kg ha^{-1}) were evaluated for protein content, protein yield per hectare and some starch characteristics by Hevia *et al.* (2000). The protein content fluctuated between 16.5% (at 0 kg N ha^{-1}) and 18.4% (at 200 kg N ha^{-1}). The protein yield per hectare fluctuated between 457.2 (at 0 kg N ha^{-1}) and 973.4 kg ha^{-1} (at 300 kg N ha^{-1}) and was characterized by a quadratic regression as a response to fertilizer application. The starch characteristics were not significantly affected by any of the N levels.

Das and Ghosh (1999) conducted a field experiment on amaranth during winter, summer and rainy seasons of 1996-1997 with 4 levels of nitrogenous fertilizer @ 0, 40, 80 and 120 kg ha^{-1} in Kalyani, India. From their experiment they reported that yield components and seed yield increased with increasing N up to 120 kg N ha^{-1}.

Talukdar (1999) conducted an experiment at the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur. Different growth attributing characters was recorded and found that fertilizer dose with 200-100-200 kg ha^{-1} of urea, triple super phosphate and muriate of potash, respectively gave the highest stem yield 355.75 g $plant^{-1}$ and green yield 94.41 t ha^{-1}.

The effect of nitrogen fertilizer on amaranth yield, yield components, growth and development was investigated by Myers (1998) with five levels of nitrogen fertilizer and three cultivars. Yield was responsive to nitrogen application, but high rates of fertilizer can negatively affect grain yield.

In a field experiment during summer 1990/92 at Kinnaur, Himachal Pradesh, India by Saini and Shekhar (1998) to find out the effect of nitrogen fertilizer 0, 30, 60, 90 and 120 kg ha^{-1} on growth and yield of amaranth and reported that yield and most yield components increased significantly upto 90 kg N ha^{-1} and then decreased.

In small plot trials on dernopodzolic soil in the mountain region with 0, 60 or 120 kg ha^{-1} N fertilizer by Ozhiganova *et al.* (1996) and reported that the effect of seed inoculation on N-fixing activity in the rhizosphere varied greatly with plant growth stage and N rate but there were marked increases at flowering without N fertilizer and at fruiting with N inoculation increased plant height and aboveground and root fresh weight at all growth stages. Fresh matter yield increased from 29.9-31.2 t ha^{-1} without inoculation to 36.1, 46.8 and 43.0 t with 0, 60 and 120 kg N, respectively, when seeds were inoculated. Inoculation reduced plant nitrate content and increased crude protein content.

Acar (1996) carried out a field experiment to study the effects of nitrogen fertilizer rates on yield and yield components of two amaranth cultivars in 1995 in Samsun, Turkey, with, 3, 6, 9 or 12 kg N ha^{-1} day^{-1}. From the results it was noted that there were no significant effect of N on seed yield and yield components. There were highly significant positive correlations between seed yield and both cultivars and 1000 seed weight.

A garden experiment was carried out by Anten and Werger (1996) with amaranth grown from seed, in dense stands in which a size hierarchy of nearly equally aged individuals had developed in order to investigate how nitrogen allocation patterns in plants are affected by their vertical position in the vegetation. Canopy structure, vertical patterns of leaf nitrogen distribution and leaf photosynthetic characteristics were determined in both dominant and subordinate plants. The amount of N which is reallocated from the oldest to the younger, more illuminated leaves higher up in the vegetation may depend on the sink strength of the younger leaves for nitrogen.

Rashid (1993) reported that at the fertilizer dose of 200, 100 and 200 kg ha^{-1} with urea, super phosphate and muriate of potash, respectively amaranth gave the highest yield. The average yield at this fertilizer dose ranged from 35-40 t ha^{-1}.

Hamid *et al.* (1989) in an experiment used 200 kg urea, 100 kg triple super phosphate and 200 kg muriate of potash ha^{-1} and reported that significant variation were present among 12 amaranth lines (4 exotic and 8 local) for plant diameter which was positively correlated with yield. The exotic germplasm AM0008 was the highest yielding, producing 234.40 t ha^{-1}. Among the local germplasm highest yield produced was 122.40 t ha^{-1} and lowest yield was 42.80 t ha^{-1}. Plant height of some exotic and local lines varied from 70.20 to 131.60 cm. The number of leaves and plant diameter $plant^{-1}$ in local cultivars ranged from 72 to 162 and 5.30 to 9.30 mm, respectively.

Subhan (1989) conducted a field experiment at Lembang from August to September 1988 to find out the effect of doses N @ 0, 30, 70 and 110 kg ha^{-1} and application time of nitrogen fertilizer on growth and yield of amaranth applied as a single application at sowing or as a split application at sowing and 10 days after sowing. Leaf number and stem diameter were not affected by N application. Plant height, leaf area and fresh weight increased with increasing N application but root length was reduced by high N application. The highest yields were obtained with a split application of 110 kg N ha^{-1}.

Mohideen *et al.* (1985) conducted an experiment for an evaluation program in amaranth under the all Indian coordinated vegetable improvement project at the Tamil Nadu Agriculture University. A promising clipping type (A.83) was released as Co. 3 amaranth over local type after testing for five seasons. Fertilizer doses were 85 kg N, 60 kg P and 60 Kg K ha^{-1} respectively. The leaf stem ratio was. 2.00 and the yield performance of this stain was recorded a mean yield of 3.716 kg ha^{-1}. Highest plant height was recorded as 172.5 cm. The mean weight of 8 types of amaranth was 276 g.

Vijayakumar *et al.* (1982) conducted an experiment with nitrogen at 0, 80, 100 or 120 kg ha^{-1} and recorded plant height and which were ranged from 16.05 to 57.25 cm at 30 DAS, 34.95-70.25 cm at 45 DAS and 65 to 122.15 cm at 60 DAS from highest doses of fertilizer.

In Himachal Pradesh, at the rate of 60, 50 30 kg NPK ha^{-1}, respectively, were recommended for getting the best yield of vegetables (Anon, 1978). Grubben and Sioten (1977) in an experiment on amaranth recommended fertilizer dose of amaranth as a mixture of 10-10-20 N-P-K applied at 400 kg ha^{-1} for plants to be uprooted and at 600 kg ha^{-1} for plant to be harvested, respectively.

Intensive selection work investigated by Kamalanathan *et al.* (1973) at vegetable section, Agriculture College and Research Institute, Coimbatore has resulted with release of a new strain Co. 1 amaranth suited to Tamil Nadu. Fertilizers were used as 85 kg N, 60 kg P and 60 kg K ha^{-1}. The average yield of this new strain is 18.70 t ha^{-1} green with 31 to 51 percent increase over local types. The leaves and stems are succulent, tasty and nutritious. It can be grown throughout the year for use as 'Mulaikeerai' and 'Thandukeerai'.

2.2 EFFECT OF COW DUNG ON GROWTH AND YIELD

Suthamathy and Seran (2011) conducted an experiment to evaluate the growth and yield response of red onion (*Allium ascalonicum* L.) growth with sandy soil, cow dung, coir dust and paddy husk ash. The results indicated that potting materials have significant effect on the growth and yield of red onion grown in different potting media. Maximum number of leaves per plant, highest plant height and maximum yield were recorded in sandy soil: cattle manure: paddy husk ash at ratio of 6:2:1. It was also noted that the yield per plant increased more than two fold in sandy soil: cattle manure: paddy husk ash at ratio of 6:2:1 over control (medium 1). Usage of paddy husk ash as a potting material in medium preparation would improve the growth and yield performances of red onion grown in pot culture technique.

Parwada *et al.* (2011) found that the higher yield of sweet potato was recorded on effect of mustard oil cake compared with chicken manure.

Adewale *et al.* (2011) studied to assess the effect of different rates of poultry manure on the yield of garlic. The treatments compared were five poultry manure rates (0, 5, 10, 15, 20 t ha^{-1}). The lowest yield was obtained from the yield of the control; all the treatments had significantly higher yields than the control. The highest yield was recorded on plants that received poultry manure at 20 t ha^{-1}. This could be attributed to increase the quality of nutrients from this rate of poultry manure.

Nasreen *et al.* (2009) were investigated on the response of garlic (var. BARI Garlic-2) to zinc, boron and poultry manure application along with a blanket dose of 150 kg N, 50 kg P, 100 kg K and 40 kg S ha^{-1} was evaluated through field trails in the Grey Terrace Soil under AEZ 25. Application of zinc, boron and poultry manure had significantly increased plant height, number of leaves $plant^{-1}$, cloves $bulb^{-1}$, diameter and weight of bulb and yield ha^{-1}. The highest yields were obtained from the Zn_5B_1 kg ha^{-1} plus 5 t ha^{-1} poultry manure treatment and it was significantly higher than all other treatments.

Yahaya (2008) found the yield of garlic increased as the quality of poultry manure increased. Plants that received cow dung at 20 t ha^{-1} had the highest average number of cloves per bulb of 5.7, followed by those that received poultry manure at 15 t ha^{-1} with an average of 5.3 cloves $bulb^{-1}$. The ability of cow dung to increase the performance of garlic could also be attributable to the fact that organic manures improve both physical and chemical soil properties.

Shaheen *et al.* (2007) showed organic fertilizers has positive effect on root growth by improving the root rhizosphere conditions (structure, humidity, etc.) and also plant growth is encouraged by increasing the population of microorganisms. They also observed higher plant growth from cow dung compared to sheep manure.

Halvin *et al.* (2003) may be ascribed cow dung to increase availability of nutrients in the soil for uptake by plant roots that may have enhanced vegetative growth through increasing cell division and elongation.

Jablonska *et al.* (2002) stated that the highest yield of vegetable cultivated in the second year after organic fertilizer application were obtained after ploughing the field pea, cow dung and the mixture of oat + field pea.

Zakaria and Vimala (2002) found the high nitrogen content of composted dairy manure and cow dung has contributed to a higher yield (fresh and dry mass) of onion than that of vegetables treated with poultry manure or alkaline stabilized composted dairy manure. However, the combination of organic fertilizer (green manure, palm oil mill effluent) and inorganic fertilizer (N, P and K) produced yields of cucumber and cabbage that were higher than those of plants treated with green manure or palm oil mill effluent alone.

Belay *et al.* (2001) stated that organic fertilizers are considered as a source of organic matter for soil. It may be used as a substitute to the chemical fertilizers because it gives plants food elements for longer period and also increases soil fertility by increasing the activity of soil microorganisms.

Salman, M. (2001) showed the effect of plant growth in carrot with the application of digested poultry slaughter house waste with cow dung as nitrogen source, gave the higher yield.

Frank (2000) confirm the application of mustard oil cake which affect on number of onion leaves as it increased with an increase in the quantity of the mustard oil cake applied. Plants that received mustard oil cake at 4.5 t ha^{-1} had the highest value of number of leaves while the yield of onion also showed highest.

Rahman (2000) carried out an experiment and found that plant height of TPS seedlings was significantly influenced by the application of cow dung. The highest plant height (75.28 cm) at 100 days was obtained from the highest dose of cow dung (100 t ha^{-1}).

Nambiar *et al.* (1998) showed sustainable crop production could be possible through the integrated use of organic manure and chemical fertilizers. A suitable combination of organic and inorganic sources of nutrients is necessary for a sustainable agriculture that will provide good quality true seeds of onion. Integrated use of organic manures and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining higher soil fertility status.

Singer *et al.* (1998) found that addition of organic fertilizer improves soil structure, which can encourage root development and leads to encourage growth of different crops.

Barman and das (1996) treated green gram (*Vigna radiata*) with organic amendments: cow dung, poultry manure and mustard oil cake each at 2 t ha^{-1} alone and highest yields were given by mustard oil cake.

Meena and Gupta (1996) conducted a field experiment by supplying 10 t ha^{-1} of FMY, Gobar gas spent slurry or digested willow dust, or 3 t mustard oil cake, or 0-120 kg N ha^{-1} to potato cv. Kufri Chandramukhi. Tuber yield was highest with mustard oil cake (16.2 t ha^{-1}) and 120 kg N (16.3 t ha^{-1}).

Barman and Das (1996) treated green gram (*Vigna radiata*) organic amendments: Neem cake, cow dung, poultry manure and mustard oil cake each at 2 t ha^{-1} alone and in combined application of seed dressing, followed by organic amendments at 1 t N ha^{-1} each. It was found effective in improving plant growth characteristics and yield.

Majumdar and Mondal (1994) made a study on the effect of soil amendment with NPK (40:20:20) and mustard and Neem oil cake on rosella (*Hibiscus sabdarifa*). The fibre yield $plant^{-1}$ in NPK and mustard oil cake at 1 t ha^{-1} were significantly higher compared with control; besides, higher disease incidence was revealed in the treated.

Adhikari *et al*. (1992) conducted a field trial on carrot cv. Kufri Badshah, gave 150 kg nitrogen as urea + 40 t cow dung, 3.2 t mustard oil cake or 20 t cow dung, 1.6 t mustard oil cake or 10 t poultry litter ha^{-1} to give a total nitrogen application in each treatment of about 310 kg ha^{-1}. Carrot yield and net profit were highest with application of 150 kg nitrogen as urea + 20 t poultry litter ha^{-1}.

Sharma *et al*. (1986) conducted field trails during 1982-84, and found that, nitrogen used as Neem cake coated urea gave significantly higher yields than nitrogen as urea. Emergence was not effect significantly.

Mondal and Chowdhury (1980) showed that, when 100, 50 or 25% of the added nitrogen was derived from groundnut cake or 50 or 25% was provided by FYM, average yields were 27.6, 26.3, 28.4, 24.7 and 22.7 t ha^{-1}, respectively.

2.3 EFFECT OF UREA AND COW DUNG ON GROWTH AND YIELD

Mazumder (2004) reported that the optimum yield of amaranth was obtained from BARI Data-1 at Bangladesh Agricultural Research Institute, Gazipur. The highest yields ranged from 30-40 t ha^{-1} as crops were sown between February to March and the fertilizer doses were 100 kg urea, 50 kg triple super phosphate, 100 kg muriate of potash and 5 ton cow dung per hectare respectively.

An experiment was carried out by Linkui *et al.* (2002) in Shanghai, China to investigate the effect of different bio-fertilizers on the yield and quality of 3-coloured amaranth. Fertilizers were applied at the rate of 1.9 kg $plot^{-1}$. Amaranth receiving bio-fertilizers showed a yield increase of 15-38% compared to those receiving exclusive vegetable fertilizers.

The effect of cow dung and nitrogen fertilizers on the growth, yield and nutrient uptake to amaranth was studied by Akanbi (2000) in Nigeria. Twelve treatments derived from a factorial combination of four levels of cow dung (0, 1.5, 3.0 and 4.5 t ha^{-1}) and three levels of fertilizer (0, 30 and 60 kg N ha^{-1}) were carried out on a sandy loam soil. The application of cow dung and N-fertilizer enhanced plant growth with respect to the control treatments. Plant height, plant diameter, number of leaves, leaf area per plant, dry matter and shoot fresh yield were all significantly affected by different levels of cow dung in combination with or without N-fertilizers.

The performance of four varieties *Amaranthus hypochondriacs* 1008, *Amaranthus hypochondriacs* K 372, *Amaranthus cruentus* I 7-GUA, *Amaranthus cruentus* 29-UAS were investigated by Jamriska (1996) by using 85 kg N, 40-60 kg P, 60-65 kg K ha^{-1} with biofertilizer in respect of seed yield, stand density and height, inflorescence length and its height and 1000 seed weight. Among varieties *Amaranthus cruentus* 17-GUA was the best with the greatest yield of 3.29 t ha^{-1}.

A comparative study on yield and quality of some amaranth genotypes was done by Hossain (1996) in the Bangabandhu Sheikh Mujibur Rahman Agricultural University. Fertilizer dose was cow dung, urea, triple super phosphate and muriate of potash as 20 t ha^{-1}, 200, 100 and 200 kg ha^{-1}, respectively. Different growth and yield contributing characters were evaluated. He found highest yield 81.24 t ha^{-1} with maximum doses of fertilizer combination.

A study was conducted by Apaza (1994) in representative areas of the central valley of Tarija in Bolivia. Two species of amaranth were evaluated for their response to eight levels of fertilizer: control treatment, chemical (40-40-20) and (80-80-40) NPK, organic (7.5 t ha^{-1}, 15 t ha^{-1} dried ovine manure), mixed (20-20-10+3.75 t ha^{-1} and 60-60-30+11.25 t ha^{-1}). Highest response was found both chemical and mixed fertilizer 80% and 295 higher than control treatment and organic respectively.

Moniruzzaman (1987) reported that optimum yield of amaranth could be found at the rate of 10-12 t cow dung, 12 kg urea, 8-10 kg triple super phosphate and 5-7 kg muriate of potash $bigha^{-1}$, respectively.

Rajagopal *et al.* (1977) reported from a total of 65 types of amaranth were assembled from all over Tamil Nadu and other parts of India and evaluated for yield of greens and others attributes from 1972 onwards by applying recommended fertilizer and organic manure. The Co. 1 was used as standard for this evaluation. Further work on the improvement program of this crop in Tamil Nadu Agricultural University by Department of Horticulture, resulted in identification of A. 25 as a promising selection with high yield potential coupled with good edible plant qualities.

Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The field experiment was conducted at the farm in Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from April, 2014 to May, 2014 to find out the effects of different levels of nitrogen fertilizer as urea and cow dung application on the growth and yield of green amaranth. The materials and methods for conducted the experiment are presented in this chapter under the following headings:

3.1 Experimental site

The experiment was conducted at the Central Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The experimental site is situated in 23°41' N latitude and 90°22' E longitude at an altitude of 8.6 meter above the sea level (Anon., 2004).

3.2 Experimental duration

The field research work was carried out at the Sher-e-Bangla Agricultural University during the period from 12 April to 31 May, 2014.

3.3 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and was shallow red brown terrace soil. The selected experimental plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot have been presented in Appendix I(a) and I(b), respectively.

3.4 Climate

The geographical location of the experimental site was under subtropical climatic region, characterized by heavy rainfall during the months from April to September (Kharif season) and scantly rainfall during the rest of the year (Rabi season). Details of the meteorological data related to the temperature, relative humidity and rainfalls during the period of the experiment was collected from the Bangladesh Meteorological Department (Climate Division), Sher-e-Bangla Nagar and have been presented in Appendix II.

3.5 Planting materials

Seeds of green amaranth were used as planting materials in this experiment. The variety name of amaranth is BARI Danta-1. It is a green stem and leafy type quick growing short duration summer vegetable. The seed of green amaranth were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.6 Treatment of the experiment

The experiment had two factors:

Factor A: 4 levels of nitrogen fertilizer–

I. N_0: 0 kg N ha^{-1} (control)
II. N_1: 75 kg N ha^{-1}
III. N_2: 100 kg N ha^{-1}
IV. N_3: 125 kg N ha^{-1}

Factor B: 4 levels of cow dung -

I. C_0 : 0 t CD ha^{-1} (control)
II. C_1 : 2.5 t CD ha^{-1}
III. C_2 : 5.0 t CD ha^{-1}
IV. C_3 : 7.5 t CD ha^{-1}

There were 16 treatment combinations such as N_0C_0, N_0C_1, N_0C_2, N_0C_3, N_1C_0, N_1C_1, N_1C_2, N_1C_3, N_2C_0, N_2C_1, N_2C_2, N_2C_3, N_3C_0, N_3C_1, N_3C_2 and N_1C_3.

3.7 Experimental design

The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. An area of 27 m x 8.5 m was divided into three equal blocks. Each block was divided into 16 plots where 16 treatment combinations were allotted at random. There were 48 unit plots altogether in the experiment. The size of the each unit was 2.5 m x 1.4 m. The distance maintained between two blocks and two plots were 0.50 m and 0.25 m respectively.

3.8 Germination test

Germination test was performed before sowing the seeds in the field. For laboratory test, petridishes were used. Filter papers were placed on petridishes and the papers were wetten with water. Seeds were set for germination at random in petridish. Data on emergence were collected on percentage basis by using the following formula:

$$\text{Germination (\%)} = \frac{\text{Number of germinated seeds}}{\text{Number of seeds set for germination}} \times 100$$

3.9 Land preparation

The plot selected for conducting the experiment was opened in the first week of April, 2014 with a power tiller and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth condition. Weeds and stubbles were removed and finally a desirable tilth of soil was obtained for sowing green amaranth seeds. The experimental plot was partitioned into sixteen unit plots. Well-decomposed cow dung manure and chemical fertilizers were mixed with the soil of each unit plot.

3.10 Seed sowing

Seeds of BARI Data-1 were sown in the field on 12 April, 2014 in 1-2 cm deep furrows made by hand rake with maintaining the distance 25 cm between rows. The seed rate was 2 kg ha^{-1}.

3.11 Application of manure and fertilizers

The sources of N, P_2O_5, K_2O were urea, tri super phosphate (TSP) and muriate of potash (MOP), respectively. The entire amount of TSP, MOP and one third ($^1/_3$) amount of urea were applied during the final land preparation. Remaining urea was applied in two equal installments at 17 and 34 days after sowing seeds. Total amount of well-decomposed cow dung was applied during final land preparation. The amount of manure and fertilizers used are mentioned in Table a.

Table a. Doses and method of manure and fertilizers application in green amaranth field

Manure and Fertilizers	Doses ha^{-1}	Application (%)		
		Basal	17 DAS	34 DAS
Cow dung	As treatment	100	--	--
N (as Urea)	As treatment	33.33	33.33	33.33
P_2O_5 (as TSP)	25 Kg	100	--	--
K_2O(as MOP)	50 Kg	100	--	--

3.12 Intercultural operation

When the seedlings started to emerge, the bed was always kept under careful observation. After emergence of seedlings, various intercultural operations like thinning, weeding, top dressing were accomplished for better growth and development of green amaranth seedlings.

3.12.1 Irrigation and drainage

Over-head irrigation was provided with a watering can to the plots once immediately after germination in every alternate day in the evening up to first thinning. Further irrigation was done as and when needed. Stagnant water was effectively drained out at the time of heavy rain.

3.12.2 Thinning

First thinning was done at 15 days after sowing (DAS), 2nd thinning was done at 30 DAS and 3rd was done at 40 days after sowing for proper growth and development of green amaranth seedlings.

3.12.3 Weeding

Weeding was done to keep the plots free from weeds and easy aeration of soil which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully after complete emergence of amaranth seedlings whenever it was necessary. Demarcation boundaries and drainage channels were also kept weed free. The weeding was done manually with Nirani.

3.12.4 Top dressing

After basal dose, the remaining doses of urea were top-dressed in two equal installments, 17 and 34 days after sowing respectively. The fertilizers were applied on both sides of plant rows and mixed well with the soil by hand. Earthing up was done with the help of nirani immediately after top-dressing of urea fertilizer.

3.13 Plant protection

For controlling stem rot of green amaranth Ripcord 1 mL L^{-1} water was applied once 32 days after sowing soon after the appearance of infestation. The spraying was done in the afternoon while the pollinating bees were away from the field. There was no other remarkable attack of insect or pests.

3.14 Harvest and post harvest operation

To evaluate yield, harvesting was done at 50 days after sowing (DAS) at 31 May, 2014. Different yield contributing data were recorded from the mean of ten harvested sample plants which were selected at random from different places of each plot leaving border plants. After collection of the sample, harvesting was done. The harvested crops of each plot were tied into bundled and tagged separately, carried to the farm house and recorded different parameters. After sun drying, the crops were kept in oven for further data collection.

3.15 Data collection

The experimental data were recorded from 20 DAS and continued until harvest. Ten plants were randomly selected from each unit plot for the collection of data while the whole plot crop was harvested to record per plot data. Dry weights of different plant parts were taken after oven drying. The data were recorded on the following parameters from the sample plants during the course of experiment.

1. Plant height (cm) at 20, 30, 40 DAS and at harvest.
2. Number of leaves $plant^{-1}$ at 20, 30, 40 DAS and at harvest.
3. Stem diameter (mm) $plant^{-1}$ at 30, 40 DAS and at harvest.

4. Leaf greenness at 30, 40 DAS and at harvest.
5. Fresh and dry weight (g) of leaves plant^{-1}
6. Fresh and dry weight (g) of stem plant^{-1}
7. Fresh and dry weight (g) of root plant^{-1}
8. Root length (cm) plant^{-1}
9. Stem-leaf ratio (on fresh weight basis)
10. Leaf yield (t ha^{-1})
11. Stem yield (t ha^{-1})
12. Green yield (t ha^{-1})

3.16 Procedure of data collection

3.16.1 Plant height

The height of plant was recorded in centimeter (cm) at 20, 30, 40 days after sowing and at harvest in the experimental plots. The height was measured from the ground level up to the tip of the growing point.

3.16.2 Number of leaves plant^{-1}

Number of leaves plant^{-1} was counted at an interval of 10 days starting from 20 DAS upto harvest. Leaves number plant^{-1} were recorded by counting all leaves from each of randomly selected ten plants. Mean value of data were calculated and recorded.

3.16.3 Stem diameter

Stem diameter of amaranth plant was measured in millimeter (mm) with a thread and then a meter scale as the outer surface of the stem. Data were recorded as the average of 5 random selected plants from the inner rows of each plot starting from 30 to 50 DAS at 10 days interval and mean value for each stem diameter was recorded.

3.16.4 Leaf greenness

Leaf greenness is an important character of leaves which can be recommended as the presence of chlorophyll concentration and nitrogen. Most green related colors of leaves are sourced from chlorophyll a and b. The chlorophyll meter Soil Plant Analysis Development (SPAD-502) is a simple, handheld and portable diagnostic tool that measures the greenness or the relative chlorophyll concentration of leaves (Kariya *et al.,* 1982; Torres-netto *et al.,* 2005). It provides instantaneous and non-destructive readings on plants based on the quantification of the intensity of absorbed light by the tissue sample using a red LED (wavelength peak is ~650 nm) as a source. An infrared LED, with a central wavelength emission of approximately 940 nm, acts simultaneously with the red LED to compensate for the leaf thickness (Minolta camera Co. Ltd., 1989).

Leaf greenness was measured at 30, 50 and 90 DAS. Mature leaf (fourth leaves from top) were measured all time. Leaf greenness of five mature plants of each plot were measured by using portable SPAD-502 (Minolta, Japan) and the collected values were finally averaged.

3.16.5 Fresh and dry weight of leaves plant^{-1}

After harvest, the fresh weight (g) of the leaves from the pre-selected 10 plants was taken first. Then the samples of leaves were dried in oven at 70°C for 72 hours and weight was taken in gram carefully. The collected data were finally averaged.

3.16.6 Fresh and dry weight of stem plant^{-1}

The stems of randomly selected ten plants were weighed just after harvest. Then the plant samples were oven dried at 70°C for 72 hours and measured carefully with the help of electric balance. Thus the fresh and dry weight (g) of stem were collected and finally averaged.

3.16.7 Fresh and dry weight of root plant^{-1}

The roots of randomly selected ten plants were uprooted, blotted and weighed just after harvest. Then the plant samples were oven dried at 70°C for 72 hours and measured carefully using an electrical balance. Thus the fresh and dry weight (g) of root were collected and finally averaged.

3.16.8 Root length

The length of root was recorded in centimeter (cm) at 30, 40 days after sowing and at harvest in the experimental plots. The length of tap root was measured from the base or ground level up to the tip of the growing point.

3.16.9 Stem-leaf ratio (on fresh weight basis)

The fresh weight of stem and the fresh weight of leaf collected from the randomly selected plants of each treatment were expressed in ratio. The mean results were recorded.

3.16.10 Leaf yield

The crop of each unit plot was harvested and separated the leaves and took weight. The leaves yield was recorded in terms of kg m^{-2}. Thereafter the yield was converted to t ha^{-1}.

3.16.11 Stem yield

The crop of each unit plot was harvested and separated the stem and took weight. The stem yield was recorded in terms of kg m^{-2}. Then the yield was converted to t ha^{-1}.

3.16.12 Green yield

The summation of leaf yield and stem yield ha^{-1} was considered as green or biological yield. It was calculated on fresh weight basis by using the following formula:
Green yield (t ha^{-1}) = Leaf yield (t ha^{-1}) + Stem yield (t ha^{-1})

3.17 Statistical Analysis

The recorded data for different parameters were compiled and tabulated in proper form and were subjected to statistical analysis. Analysis of variance (ANOVA) was done following the computer package MSTAT-C program developed by Russel, 1986. The mean differences among the treatments were adjusted by least significant difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984) for interpretation results.

Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

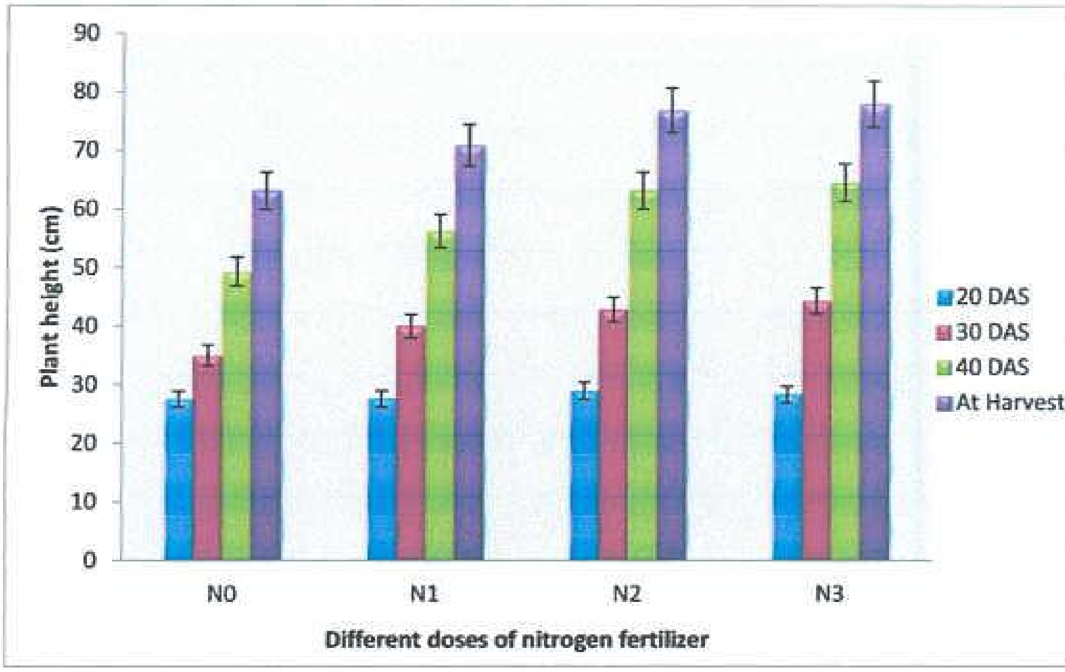
The experiment was conducted to find out the effect of urea as nitrogen fertilizer and cow dung on the growth and yield of green amaranth. The results obtained from the study have been presented, discussed and compared in this chapter through table(s), figures and appendices. The analysis of variance (ANOVA) of data in respect of all the parameters has shown in Appendix III-IX. The results have been presented and discussed with the help of table and graphs and possible interpretations given under the following headings:

4.1 Plant height

4.1.1 Effect of urea

Plant height (cm) of green amaranth varied significantly due to the individual application of different level of nitrogen as urea fertilizer at 20, 30 and 40 DAS and at harvest (Figure 1 and Appendix III). At 20 DAS, the N_2 treatment gave the longest plant (28.90 cm) which was statistically similar with the N_3 (28.34 cm) while the control or N_0 gave the shortest plant i.e. 27.53 cm which was statistically similar with the N_1 (27.58 cm). At 30 DAS, the longest plant (44.32 cm) was observed from the N_3 treatment while the shortest (35.02 cm) was found from the N_0 treatment. At 40 DAS, the longest plant (64.55 cm) was recorded from the N_3 treatment and the shortest (49.28 cm) was from the N_0 treatment. At harvest, the highest plant height (77.98 cm) was found from the N_3 treatment which was statistically similar to the N_2 treatment (76.82 cm) and lowest plant height (63.13 cm) was found from the N_0 treatment.

These results indicated that urea increases the growth of stem amaranth to ensure the longest plant than control. Probably highest amount of nitrogen ensured the favorable condition for vegetative growth as a result highest amount of nitrogen produced longest plant than the others. The results of this study were similar to the findings of Miah *et al.* (2013), Olaniyi *et al.* (2008), Hamid *et al.* (1989) and Vijayakumar *et al.* (1982).



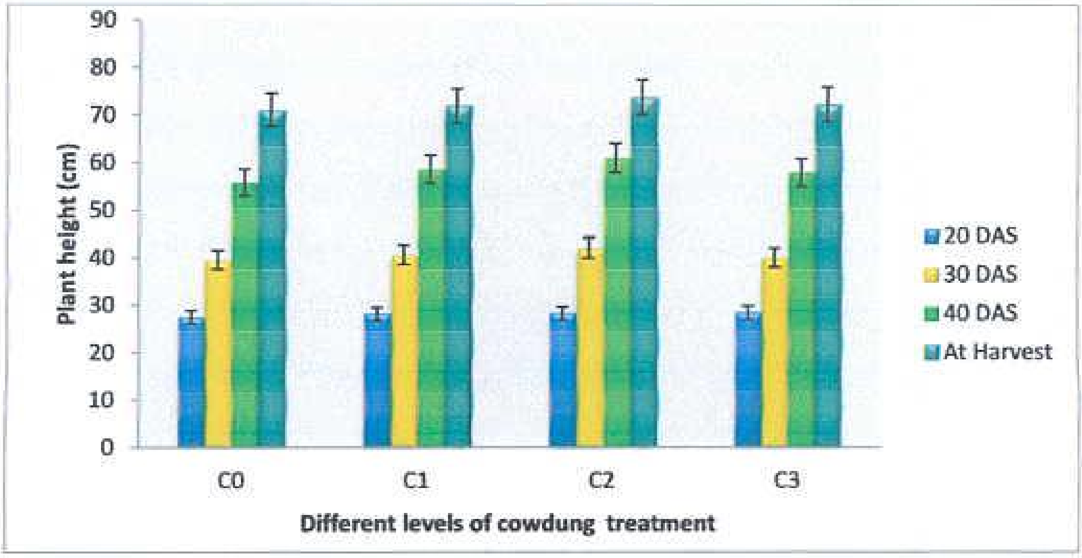
Note: N_0 = 0 kg ha^{-1} (control), N_1 = 75 kg ha^{-1}, N_2 = 100 kg ha^{-1}, N_3= 125 kg ha^{-1}

Figure 1. Effect of urea on plant height (cm) of green amaranth at different growth stages

4.1.2 Effect of cow dung

Plant height is one of the most important parameters, which is positively correlated with the plant yield. Plant height (cm) of green amaranth was recorded at 20, 30 and 40 days after sowing (DAS) and at the final harvest. A marked variation in plant height was observed due to the influence of cow dung (Figure 2 and Appendix III). At 20 DAS, green amaranth showed statistically insignificant regarding plant height. Numerically the highest plant height (28.48 cm) was found from the C_3 treatment and the lowest plant height (27.41 cm) was found from the N_0 treatment. At 30 DAS, the longest plant (42.00 cm) was observed from the C_2 treatment while the shortest (39.53 cm) was found from the N_0 treatment. At 40 DAS, the longest plant (60.98 cm) was recorded from the C_2 treatment and the shortest (55.75 cm) was from the N_0 treatment. At harvest, the highest plant height (73.68 cm) was found from the C_2 treatment and the lowest plant height (70.98 cm) was found from the C_0 treatment.

Obtained results on plant height were similar to those reported by Islam (2011), Roy (2008) and Kabir (2007). Jin *et al.* (1996) reported that plant height was higher at optimum cattle manure application than higher doses.



Note: C_0 = 0 t ha^{-1} (control), C_1 = 2.5 t ha^{-1}, C_2 = 5 t ha^{-1}, C_3 = 7.5 t ha^{-1}

Figure 2. Effect of cow dung on plant height (cm) of green amaranth at different growth stages

4.1.3 Interaction effect of urea and cow dung

The variation was found due to the interaction effect of nitrogen and cow dung on plant height of green amaranth at different days after sowing (Table 1). The longest plant (29.87 cm) was recorded at 20 DAS from the combined effect of N_2C_3, while control treatment i.e. N_0C_0 gave the shortest plant (26.73 cm) which was statistically similar to the N_1C_0 treatment (26.57 cm). At 30 DAS, significant variation in terms of plant height was also observed among the treatment combinations and the longest plant (46.47 cm) was observed from the treatment combination of N_2C_2 which was statistically similar to N_3C_0 (44.20 cm), N_3C_1 (45.20 cm) and N_3C_2 (44.60 cm) whereas the shortest (34.00 cm) was recorded from control treatment, N_0C_0 which was statistically similar to N_0C_1 (34.67 cm), N_0C_2 (35.53 cm) and N_0C_3 (35.87 cm). At 40 DAS, the tallest plant (67.80 cm) was recorded from the N_2C_2 treatment which was statistically similar to N_3C_1 (66.40 cm) and N_3C_2 (65.40 cm) and the shortest (46.40 cm) was found from the N_0C_0 treatment. At harvest, the highest plant height (80.53 cm) was found from the N_2C_2 treatment which was statistically similar to N_3C_1 (79.60 cm) and the lowest plant height (62.40 cm) was found from the N_0C_0 treatment which was statistically similar to the N_0C_1 (62.87 cm), N_0C_2 (62.80 cm) and N_0C_3 (64.47 cm).

From the results it was revealed that both nitrogen and cow dung favored the plant height (Talukder, 1999). Plant height data recorded in the current experiments coincided with those reported by Hamid *et al.* (1989), Mohideen *and Subramanian* (1974) and Rajgopal *et al.* (1977).

Table 1: Interaction effect of different doses of nitrogen fertilizer and cow dung on plant height (cm) at different days after sowing

Treatment		Plant height (cm)			
		20 DAS	30 DAS	40 DAS	At Harvest
N_0	C_0	26.73 b	34.00 h	46.40 i	62.40 h
	C_1	27.73 ab	34.67 h	49.20 h	62.87 h
	C_2	27.80 ab	35.53 gh	50.67 gh	62.80 h
	C_3	27.87 ab	35.87 gh	50.87 gh	64.47 h
N_1	C_0	26.57 b	38.50 fg	52.73 g	67.67 g
	C_1	27.13 ab	41.00 def	56.73 f	71.40 ef
	C_2	28.47 ab	41.40 cdef	60.07 e	73.87 de
	C_3	28.13 ab	38.93 ef	55.53 f	70.60 f
N_2	C_0	28.27 ab	41.40 cdef	60.13 e	76.40 cd
	C_1	29.13 ab	41.47 cdef	62.13 de	73.73 de
	C_2	28.33 ab	46.47 a	67.80 a	80.53 a
	C_3	29.87 a	42.00 cde	62.60 cde	76.60 cd
N_3	C_0	28.07 ab	44.20 abcd	63.73 bcd	77.47 bc
	C_1	28.60 ab	45.20 ab	66.40 ab	79.60 ab
	C_2	28.63 ab	44.60 abc	65.40 abc	77.53 bc
	C_3	28.07 ab	43.27 bcd	62.67 cde	77.33 bc
$LSD_{(0.05)}$		2.625	2.938	2.746	2.683
CV (%)		13.47	10.82	6.56	5.75
Level of significance		*	*	*	*

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 5% level of probability.
* - indicate significant at 5% level

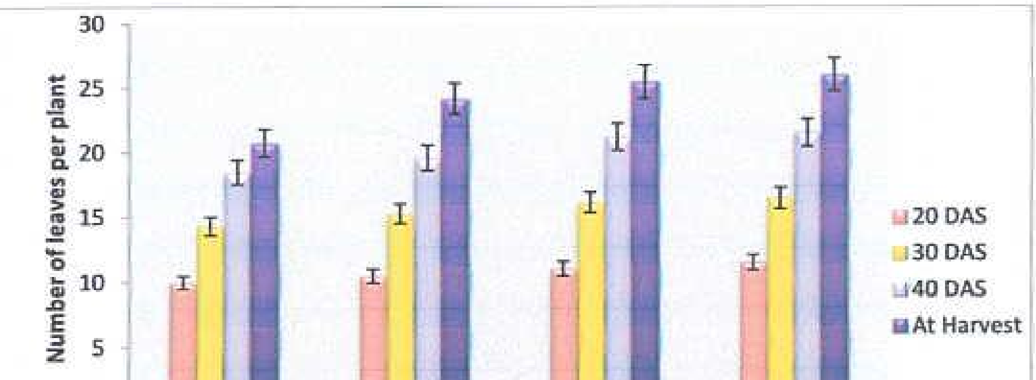
Note: N_0 = 0 kg ha^{-1} (control), N_1 = 75 kg ha^{-1}, N_2 = 100 kg ha^{-1}, N_3 = 125 kg ha^{-1}
C_0 = 0 t ha^{-1} (control), C_1 = 2.5 t ha^{-1}, C_2 = 5 t ha^{-1}, C_3 = 7.5 t ha^{-1}

4.2 Number of leaves

4.2.1 Effect of urea

Different doses of nitrogen fertilizer application exhibited significant variation in respect of number of leaves plant^{-1} of green amaranth at 20, 30, 40 DAS and at harvest (Figure 3 and Appendix IV).The number of leaves plant^{-1} increased with advancing growing period up to 40 DAS harvest and thereafter showed statistically insignificant increase of leaves plant^{-1}. At 20 DAS, the N_3 showed highest (11.43) number of leaves plant^{-1} while the lowest (9.942) number of leaves plant^{-1} was observed from N_0 treatment. At 30 DAS, the highest number of leaves plant^{-1} was counted from the N_3 (16.38) which were statistically similar with the N_2 (16.07) over the control (14.27). At 40 DAS, the N_3 showed highest (21.48) number of leaves which was statistically similar with the N_2 (21.15) whereas the lowest (20.73) was observed from N_0 treatment. At harvest the maximum number of leaves plant^{-1} was 25.97 from the N_3 which was statistically similar with the N_2 (25.43) whereas the lowest (20.73) was observed from N_0 treatment.

Application of higher nitrogen doses reported to increase growth of green amaranth (Arfin, 2006 and Acar, 1996). Similar trends of results were observed from the experiment conducted by Miah (2013), Begum (2007), Yung *et al.* (2003) and Talukder (1999), Olaniyi and Ojetayo (2012) recommended that applying 90 kg N ha^{-1} or 120 kg N ha^{-1} increased number of leaves significantly.



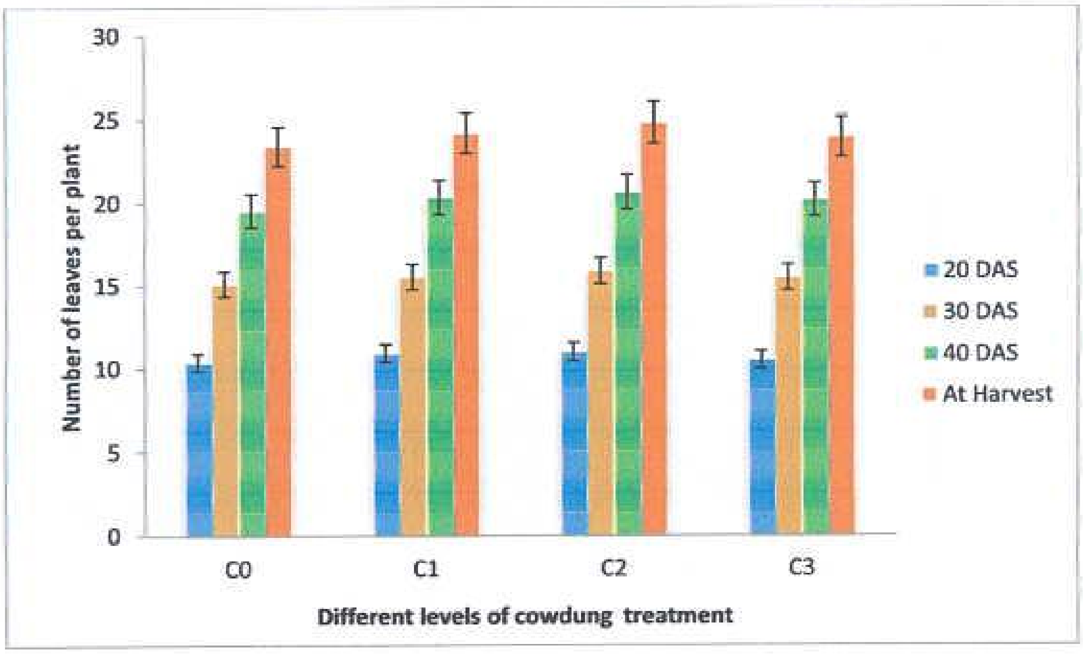
Note: N_0 = 0 kg ha^{-1} (control), N_1 = 75 kg ha^{-1}, N_2 = 100 kg ha^{-1}, N_3 = 125 kg ha^{-1}

Figure 3. Effect of urea on number of leaves plant^{-1} of green amaranth at different growth stages

4.2.2 Effect of cow dung

The different cow dung application showed variation in number of leaves plant^{-1} at different days after sowing till harvest (Figure 4 and Appendix IV). The production of leaf number in various treatments showed no significant difference at 20 DAS and 30 DAS. Numerically at 20 and 30 DAS, the maximum number of leaves was observed from C_2 (10.98 and 15.10) where the C_0 treatment gave the minimum number (10.36 and 15.10, respectively). However, the highest number of leaf (20.62)) was counted from the C_2 at 40 DAS though it was statistically similar with C_1 (20.32) where the lowest number of leaf (19.52) was counted from the C_0. At harvest, the highest number of leaves (24.80) plant^{-1} was observed from C_2 where the C_0 treatment gave the minimum number (23.37) of leaves plant^{-1}.

Talukder (1999) reported that the similar pattern of insignificant leaf number production in all the cow dung treatments and thus was similar to those reported by Fazal *et al.* (2013). But production of greater number of leaves showed significant results in the experiment conducted by Rahman *et al.* (2012) and Kabir (2007).



Note: $C_0 = 0$ t ha^{-1} (control), $C_1 = 2.5$ t ha^{-1}, $C_2 = 5$ t ha^{-1}, $C_3 = 7.5$ t ha^{-1}

Figure 4. Effect of cow dung on number of leaves plant^{-1} of green amaranth at different growth stages

4.2.3 Interaction effect of urea and cow dung

Interaction effect of nitrogen and cow dung fertilizer doses showed significant variation on number of leaves plant^{-1} of green amaranth at 20, 40 DAS and at harvest except 30 DAS (Table 2). The results from 30 DAS leaves number revealed that numerically the maximum number of leaves plant^{-1} (16.80) was obtained from N_2C_2 while the lowest (13.53) was obtained from N_0C_0. At 20 DAS, the highest number of leaves plant^{-1} (12.57) was observed from the N_3C_1 treatment whereas the lowest (9.63) was observed from N_0C_0 treatment which was statistically similar to N_0C_1 (9.90). A similar trend was also observed at 40 DAS and at harvest in regards to doses of nitrogen fertilizer along with cow dung application and leaf production rate. At 40 DAS, the maximum number of leaves (22.67) plant^{-1} was obtained from N_3C_1 while the lowest (17.53) was obtained from control condition. At harvest, the highest number of leaves (27.20) was recorded from N_2C_2 and the lowest (19.33) number of leaves plant^{-1} was found in control plots.

It was appeared that the number of leaves increased with the increasing doses of nitrogen and cow dung together with the advancement of time (Rahman *et al.*, 2012). Akand *et al.*, 2014 concluded that application of different doses of nitrogen together with organic manures significantly produced the higher number of leaves per plant in Indian spinach. Although Fazal *et al.* (2013) and Talukder (1999) reported insignificant result in case of green amaranth leaves number.

Table 2: Interaction effect of different doses of nitrogen fertilizer and cow dung on number of leaves plant^{-1} at different days after sowing

Treatment		Number of leaves plant^{-1}			
		20 DAS	30 DAS	40 DAS	At Harvest
N_0	C_0	9.633 c	13.53	17.53 g	19.33 g
	C_1	9.900 c	14.20	18.40 fg	20.87 f
	C_2	10.07 bc	14.87	18.60 fg	21.20 f
	C_3	10.17 bc	14.47	19.33 ef	21.53 f
N_1	C_0	10.30 bc	14.93	19.40 def	23.53 e
	C_1	10.47 bc	15.33	19.53 def	24.33 de
	C_2	10.60 bc	15.60	19.80 def	24.73 cde
	C_3	10.30 bc	15.00	19.47 def	23.93 e

Table 2 (Cont'd).

Treatment		Number of leaves plant^{-1}			
		20 DAS	30 DAS	40 DAS	At Harvest
N_2	C_0	10.60 bc	15.73	20.60 cde	24.80 cde
	C_1	10.70 bc	15.73	20.67 cde	24.93 cde
	C_2	11.87 ab	16.80	22.33 ab	27.20 a
	C_3	10.70 bc	16.00	21.00 bcd	24.80 cde
N_3	C_0	10.90 abc	16.20	20.60 cde	25.80 bc
	C_1	12.57 a	16.73	22.67 a	26.53 ab
	C_2	11.40 abc	16.20	21.73 abc	26.07 abc
	C_3	10.87 abc	16.40	20.93 bcde	25.47 bcd
LSD $_{(0.05)}$		1.642	-	1.478	1.306
CV (%)		12.75	9.2	5.52	4.11
Level of significance		*	NS	*	*

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 5% level of probability.
* - indicate significant at 5% level
NS: Not significant

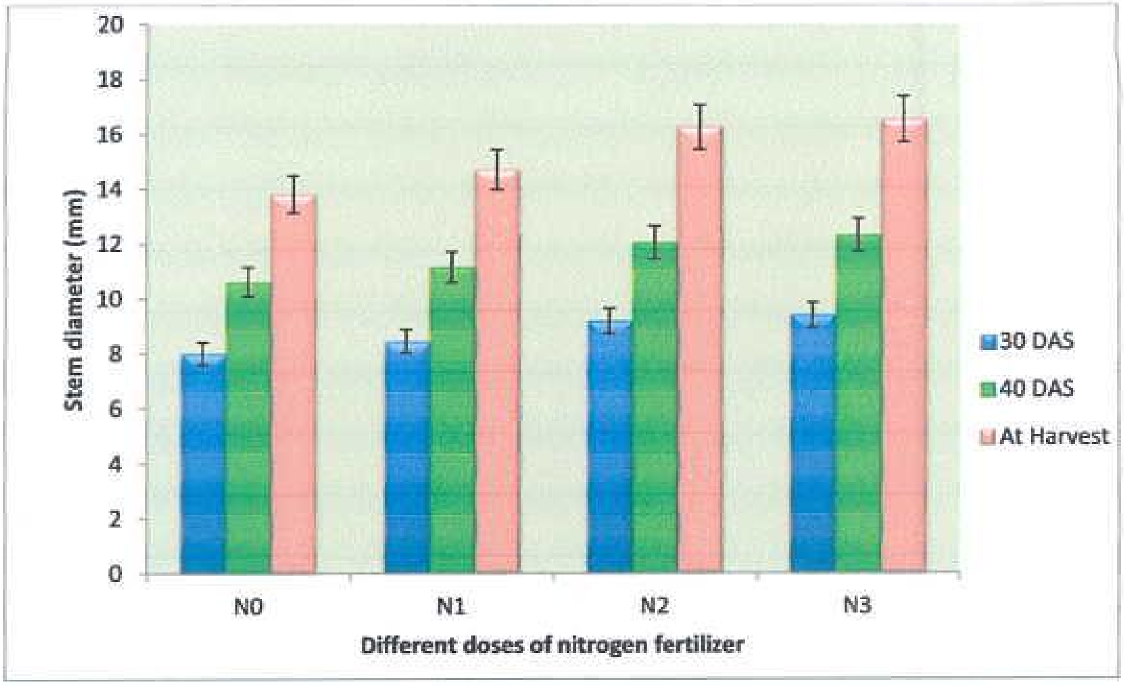
Note: N_0 = 0 kg ha^{-1} (control), N_1 = 75 kg ha^{-1}, N_2 = 100 kg ha^{-1}, N_3 = 125 kg ha^{-1}
C_0 = 0 t ha^{-1} (control), C_1 = 2.5 t ha^{-1}, C_2 = 5 t ha^{-1}, C_3 = 7.5 t ha^{-1}

4.3 Stem diameter

4.3.1 Effect of urea

Significant variation was recorded for stem diameter (mm) plant^{-1} of green amaranth due to various doses nitrogen at 30, 40 DAS and at harvest (Figure 5 and Appendix V). The result showed that stem diameter increased with advancing growing period up to harvest. The maximum stem diameter was observed in the N_3 treatment at every growth stages and that were 9.398 mm, 12.31 mm and 16.54 mm at 30, 40 DAS and at harvest, respectively. The N_2 treatment (9.177, 12.04 and 16.25 mm) gave the statistically similar result with the N_3 whereas the narrowest stem diameter (7.992, 10.61 and 13.80 mm) was recorded in the control treatment at 30, 40 DAS and at harvest, respectively.

In all cases, control (or zero) N fertilization showed the lowest stem diameter (mm) plant^{-1} and N_3 produced the highest stem diameter. Saini and Shekhar (1998) and Begum (2007) reported that highest amount of nitrogen ensured favorable condition for vegetative growth as a result maximum stem diameter was observed. Similar pattern was got from the study of Miah *et al.* (2013) and Nahar (2006).

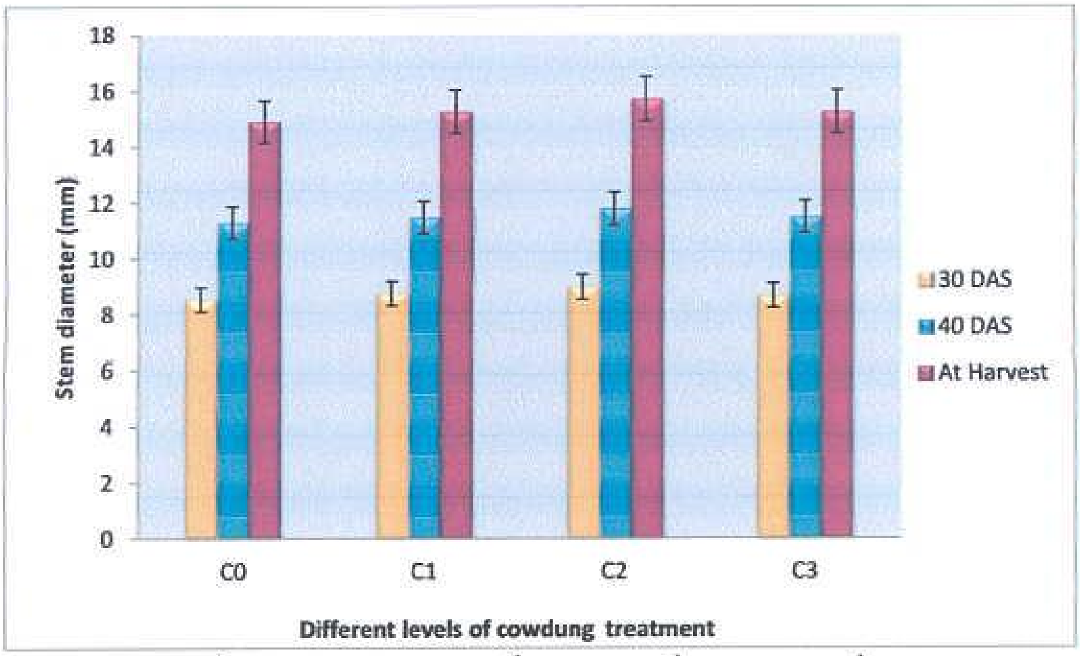


Note: N_0 = 0 kg ha^{-1} (control), N_1 = 75 kg ha^{-1}, N_2 = 100 kg ha^{-1}, N_3= 125 kg ha^{-1}

Figure 5. Effect of urea on stem diameter (mm) plant^{-1} of green amaranth at different growth stages

4.3.2 Effect of cow dung

Significant variation was recorded for stem diameter (mm) plant^{-1} of due to different cow dung treatment of green amaranth at 40 DAS and at harvest except 30 DAS (Figure 6 and Appendix V). At 30 DAS, stem diameter plant^{-1} showed insignificant result. Stem diameter increased with advancing growing period up to harvest irrespective of cow dung application. At 30, 40 DAS and at harvest, the widest stem diameter (8.999, 11.80 and 15.73 mm, respectively) was recorded from the C_3 treatment whereas, the narrowest (8.547, 11.31 and 14.92 mm, respectively) was recorded from the C_0 treatment.



Note: $C_0 = 0$ t ha^{-1} (control), $C_1 = 2.5$ t ha^{-1}, $C_2 = 5$ t ha^{-1}, $C_3 = 7.5$ t ha^{-1}

Figure 6. Effect of cow dung on stem diameter (mm) plant^{-1} of green amaranth at different growth stages

4.3.3 Interaction effect of urea and cow dung

The combination of cow dung with urea showed statistically significant effect on stem diameter (mm) plant^{-1} of green amaranth (Table 3). All the treatments yielding higher stem diameter than the control. At 30 DAS, the widest stem diameter (9.967 mm) was recorded from the N_2C_2 treatment which showed statistically similar result with the N_3C_1 (9.823 mm) whereas, the narrowest (7.783 mm) was recorded from the N_2C_2 treatment which was statistically similar with the N_0C_1 (7.920 mm). At 40 DAS and at harvest, the maximum stem diameter (12.73 and 17.28 mm, respectively) was observed in the N_2C_2 treatment whereas the narrowest stem diameter (10.31 and 13.34 mm) was recorded in the control or N_0C_0 treatment at 40 DAS and at harvest, respectively.

These results are in conformity with those of Islam *et al.* (2005) and Monira *et al.* (2007). Thus significant variations in stem diameter of green amaranth also lied in the suggestions of Rajgopal *et al.* (1977), Hossain (1996) and Talukder ((1999).

Table 3: Interaction effect of different doses of nitrogen fertilizer and cow dung on stem diameter (mm) plant^{-1} at different days after sowing

Treatment		Stem Diameter (mm) plant^{-1}		
		30 DAS	40 DAS	At Harvest
N_0	C_0	7.783 g	10.31 g	13.34 j
	C_1	7.920 g	10.48 fg	13.62 ij
	C_2	8.057 fg	10.65 fg	13.92 hij
	C_3	8.210 efg	11.00 efg	14.33 gh
N_1	C_0	8.313 defg	10.88 efg	14.23 ghi
	C_1	8.380 cdefg	11.25 cdefg	14.87 fg
	C_2	8.567 bcdefg	11.35 cdef	15.02 f
	C_3	8.510 cdefg	11.09 defg	14.67 fg
N_2	C_0	8.853 bcdef	11.84 abcde	15.71 de
	C_1	8.937 bcdef	11.73 bcde	15.67 e
	C_2	9.967 a	12.73 a	17.28 a
	C_3	8.950 bcde	11.87 abcde	15.95 de
N_3	C_0	9.240 abc	12.21 abc	16.39 bcd
	C_1	9.823 a	12.49 ab	16.92 ab
	C_2	9.407 ab	12.47 ab	16.69 abc
	C_3	9.123 abcd	12.08 abcd	16.15 cde
LSD $_{(0.05)}$		0.8051	0.9049	0.6398
CV (%)		5.57	5.31	4.64
Level of significance		*	*	*

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 5% level of probability.
* - indicate significant at 5% level

Note: N_0 = 0 kg ha^{-1} (control), N_1 = 75 kg ha^{-1}, N_2 = 100 kg ha^{-1}, N_3 = 125 kg ha^{-1}
C_0 = 0 t ha^{-1} (control), C_1 = 2.5 t ha^{-1}, C_2 = 5 t ha^{-1}, C_3 = 7.5 t ha^{-1}

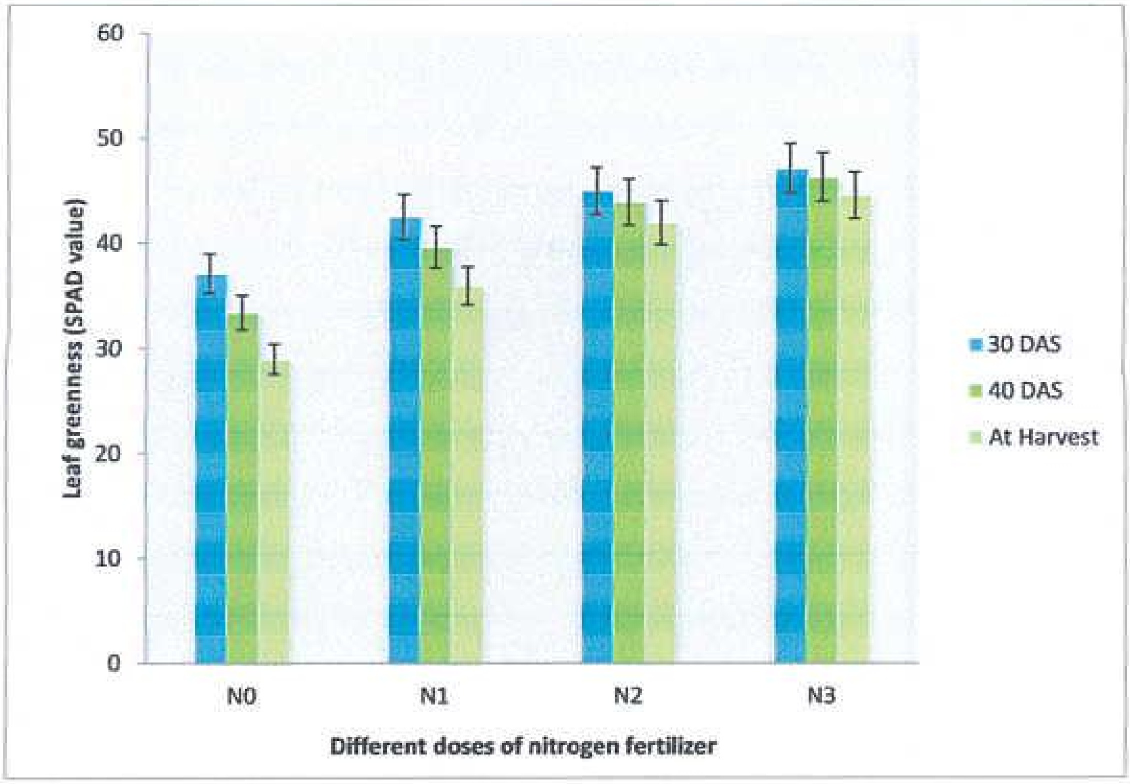
4.4 Leaf greenness

Leaf greenness as measured by a chlorophyll meter (SPAD-502) was positively correlated with nitrogen content in leaf as well as its photosynthesis at growth stages. Chlorophyll readings are quick, reliable and repeatable indicators of leaf photosynthetic rate that can be used for determining the amount of availability of nitrogen (Morrison *et al.*, 1995). Lower leaf greenness indicates shortage of nitrogen in plant cell while greater shows abundance of nitrogen in plant. When green amaranth germinates, its growth rate becomes high progressively with increasing of photosynthetic rate and show higher leaf greenness. When shortage of nitrogen appears, its growth reduces along with photosynthetic activity and run out of nitrogen content. So leaves become yellow and leaf greenness decrease due to changes in the accumulation and flow of nitrogen assimilates which results in the decrease of chlorophyll content in leaf (Olaniyi and Ojetayo, 2012).

4.4.1 Effect of urea

Leaf greenness or chlorophyll content of green amaranth were significantly affected by the application of different level of nitrogen at 20, 30 and 40 DAS and at harvest (Figure 7 and Appendix V). At 30 DAS, the highest reading of leaf greenness was observed from the N_3 treatment (47.15) where N_0 (37.09) gave the lowest reading. At 40 DAS, the highest leaf greenness was read from the N_3 (46.33) and the lowest was from N_0 treatment (33.36). At harvest, the maximum reading of leaf greenness was measured from the N_3 (44.58) treatment where the N_0 (28.96) showed the lowest reading. As a result, the N_3 treated plot was dark green leaves but the control plot showed reddish color leaves from which highest amount nitrogen treated plot can be identified visually.

This figure (7) showed that leaf greenness (SPAD value) of green amaranth increased with the advancement of nitrogen application and thereafter decreased due to yellowing of leaves with the advancement of plant age (Haque, 2013). This result of increased N rate agreed with the findings of Naidoo (2009), which may be attributed to increase in rate of photosynthesis as a result of increased leaf chlorophyll synthesis and nutrient efficiency of the vegetable plant.



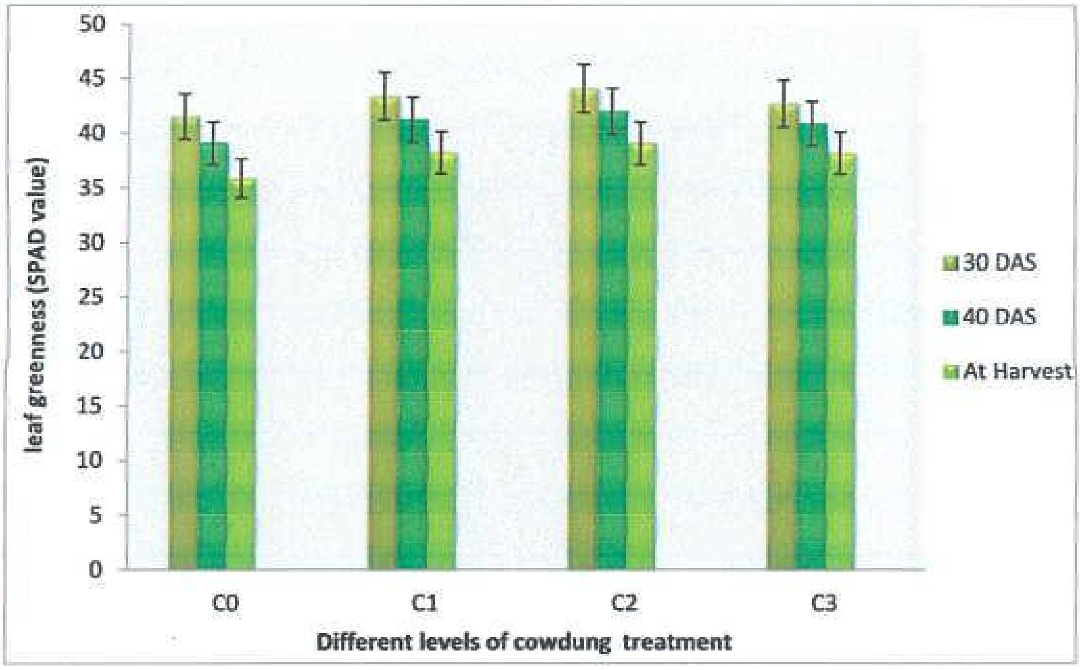
Note: N_0 = 0 kg ha^{-1} (control), N_1 = 75 kg ha^{-1}, N_2 = 100 kg ha^{-1}, N_3= 125 kg ha^{-1}

Figure 7. Effect of urea on leaf greenness of green amaranth at different growth stages

4.4.2 Effect of cow dung

The leaf greenness of green amaranth was statistically significant due to the application of cow dung at 30, 40 DAS and at harvest (Figure 8 and Appendix V). The maximum reading of leaf greenness (44.10, 42.01 and 39.09) was observed in the C_2 and the minimum reading of leaf greenness (41.49, 39.08 and 35.88) was obtained from the C_0 (46.32) at 30, 40 DAS and at harvest, respectively.

Cow dung contains different nutrients. Among them, N is one of most abundant. So the optimum application of cow dung showed similar effect as nitrogen does.



Note: $C_0 = 0\ t\ ha^{-1}$ (control), $C_1 = 2.5\ t\ ha^{-1}$, $C_2 = 5\ t\ ha^{-1}$, $C_3 = 7.5\ t\ ha^{-1}$

Figure 8. Effect of cow dung on leaf greenness of green amaranth at different growth stages

4.4.3 Interaction effect of urea and cow dung

The interaction of nitrogen and cow dung showed significant variation on leaf greenness of green amaranth at 30, 40 DAS and at harvest (Table 4). The results revealed the highest reading of leaf greenness was observed from the N_3C_1 treatment at 30, 40 DAS and at harvest which were 49.44, 48.41 and 46.40, respectively. However, the lowest was observed from N_0C_0 at all growth stages and that were 35.32 at 30 DAS, 31.64 at 40 DAS and 27.33 at harvest.

The lacking of urea and cow dung cause to deficient nitrogen which decrease chlorophyll content, reduce leaf greenness and thus cause yellowing of leaves (Haque, 2013).The variation in total chlorophyll content may be a good indicator of nitrogen content of plants (Hendry and Price, 1993; Kara and Mujdeci, 2010).

Table 4: Interaction effect of different doses of nitrogen fertilizer and cow dung on leaf greenness at different days after sowing

Treatment		Leaf greenness (SPAD value)		
		30 DAS	40 DAS	At Harvest
N_0	C_0	35.32 j	31.64 j	27.33 i
	C_1	36.60 ij	32.98 i	28.71 hi
	C_2	37.49 hi	33.89 hi	29.59 h
	C_3	38.93 gh	34.92 h	30.20 h
N_1	C_0	40.36 g	37.05 g	32.99 g
	C_1	43.52 f	40.25 f	36.17 f
	C_2	43.49 f	40.83 ef	37.37 f
	C_3	42.62 f	40.31 f	37.19 f
N_2	C_0	43.74 f	41.82 e	39.06 e
	C_1	44.02 ef	43.30 d	41.71 d
	C_2	48.26 ab	47.13 ab	45.07 ab
	C_3	43.97 ef	43.41 d	41.99 cd
N_3	C_0	46.52 cd	45.78 bc	44.13 b
	C_1	49.44 a	48.41 a	46.40 a
	C_2	47.16 bc	46.21 bc	44.33 b
	C_3	45.48 de	44.92 c	43.46 bc
$LSD_{(0.05)}$		1.534	1.306	1.652
CV (%)		2.77	2.11	3.66
Level of significance		**	**	**

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 5% level of probability.
** - indicate significant at 1% level

Note: N_0 = 0 kg ha^{-1} (control), N_1 = 75 kg ha^{-1}, N_2 = 100 kg ha^{-1}, N_3 = 125 kg ha^{-1}
C_0 = 0 t ha^{-1} (control), C_1 = 2.5 t ha^{-1}, C_2 = 5 t ha^{-1}, C_3 = 7.5 t ha^{-1}

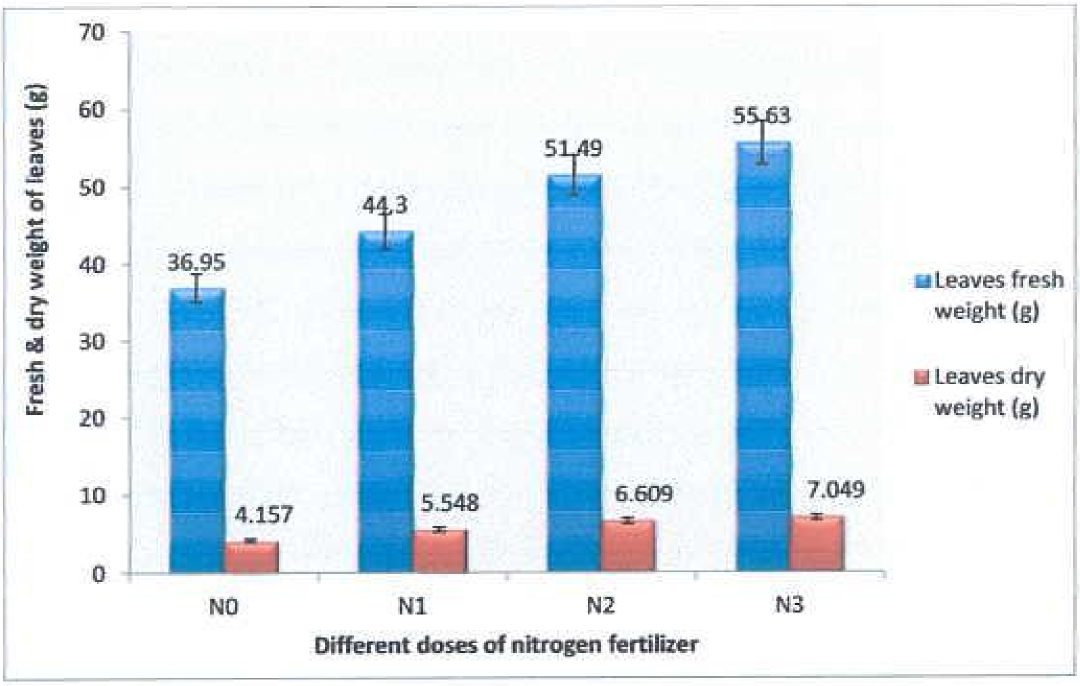
4.5 Fresh and dry weight of leaves

4.5.1 Effect of urea

The result showed that the effect of nitrogen application on leaves weight (g) plant^{-1} of green amaranth was highly significant at harvest and after oven dried (Figure 9 and Appendix VI). Just after harvest, the maximum leaves fresh weight plant^{-1} (55.63 g) was observed from the N_3 treatment whereas, the minimum fresh weight plant^{-1} (36.95 g) was observed from N_0 treatment.

After oven dry, the maximum leaves dry weight plant^{-1} (7.049 g) was measured from the N_3 treatment which was statistically similar to N_2 (6.609 g) whereas, the minimum dry weight plant^{-1} (4.157 g) was measured from N_0 treatment.

The maximum fresh weight was possibly to long time photosynthesis which leads to more deposition of photosynthates during the vegetative growth of plants (Rahman, 2006). This result agreed with the findings of Arfin (2006) and Rajagopal (1977). Das and Ghosh (1999) reported that fresh weight of leaves of stem amaranth increasing N upto 120 kg ha^{-1}.



Note: N_0 = 0 kg ha^{-1} (control), N_1 = 75 kg ha^{-1}, N_2 = 100 kg ha^{-1}, N_3 = 125 kg ha^{-1}

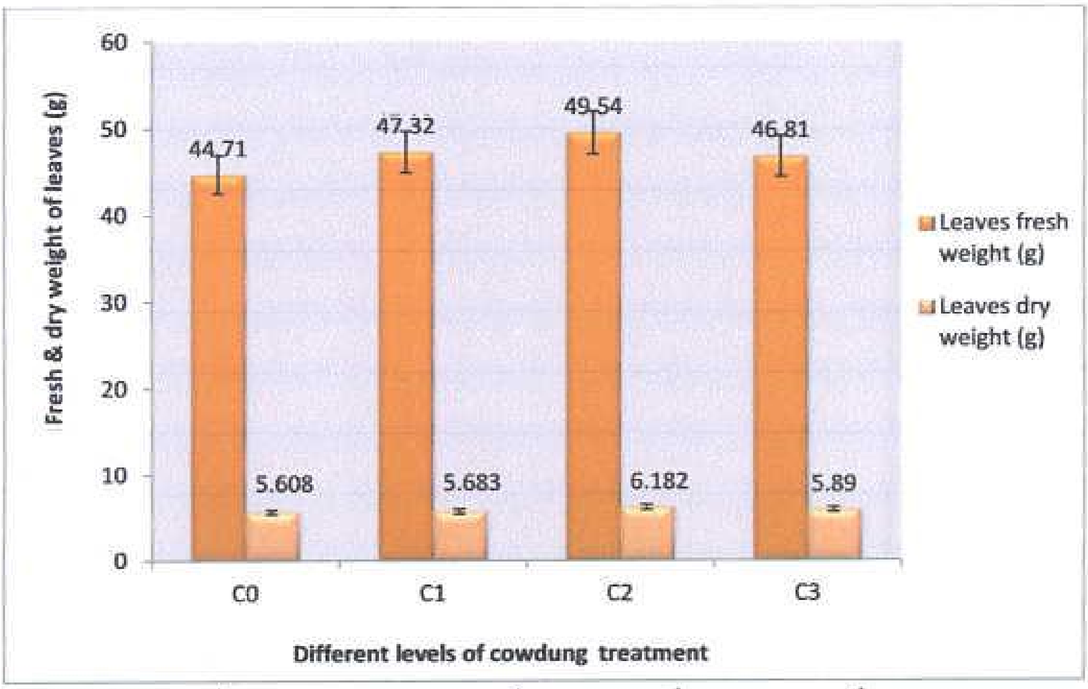
Figure 9. Effect of urea on fresh and dry weight of leaves plant^{-1} of green amaranth after harvest

4.5.2 Effect of cow dung

The fresh and dry weight (g) of leaves plant^{-1} of stem amaranth associated with the effects of various treatments is showed in Figure 10 (Appendix VI). Among the treatments, the maximum fresh weight of leaves (49.54 g) was found in C_2 encompassing those of minimum in C_0 (44.71 g).

After oven dried, the maximum leaves dry weight plant^{-1} (6.182 g) was measured from the C_2 treatment whereas the minimum leaves dry weight plant^{-1} (5.608 g) was measured from C_0 treatment.

The fresh weight production of leaves as regards to cow dung, poultry manure and urea as different N sources was compatible (Gaur et al., 1984 and Monira *et al.*, 2007).



Note: $C_0 = 0$ t ha^{-1} (control), $C_1 = 2.5$ t ha^{-1}, $C_2 = 5$ t ha^{-1}, $C_3 = 7.5$ t ha^{-1}

Figure 10. Effect of cow dung on fresh and dry weight of leaves plant^{-1} of green amaranth after harvest

4.5.3 Interaction effect of urea and cow dung

Significant variation was observed from the interaction of nitrogen and cow dung on leaves fresh and dry weight plant^{-1} of green amaranth after harvest and oven drying (Table 5). At harvest, the highest weight of fresh leaves plant^{-1} (59.80 g) was observed from the N_3C_1 treatment which was statistically similar to N_2C_2 (58.03 g) whereas, the lowest weight of fresh leaves plant^{-1} (34.60 g) was observed from N_0C_0.

After oven dry, the maximum leaves dry weight plant^{-1} (7.510 g) was measured from the N_2C_2 treatment where the minimum leaves dry weight plant^{-1} (3.860 g) was measured from N_0C_0 treatment which was statistically similar to N_0C_1 (3.900 g) and N_0C_2 (4.173 g) treatment.

Similar result was found by Oyedeji *et al.* (2014), Fazal *et al.* (2013) and Majumder (2007) who observed significant effect on leaf growth with best leaf fresh and dry matter production of stem amaranth with the combination of organic manure and inorganic fertilizer.

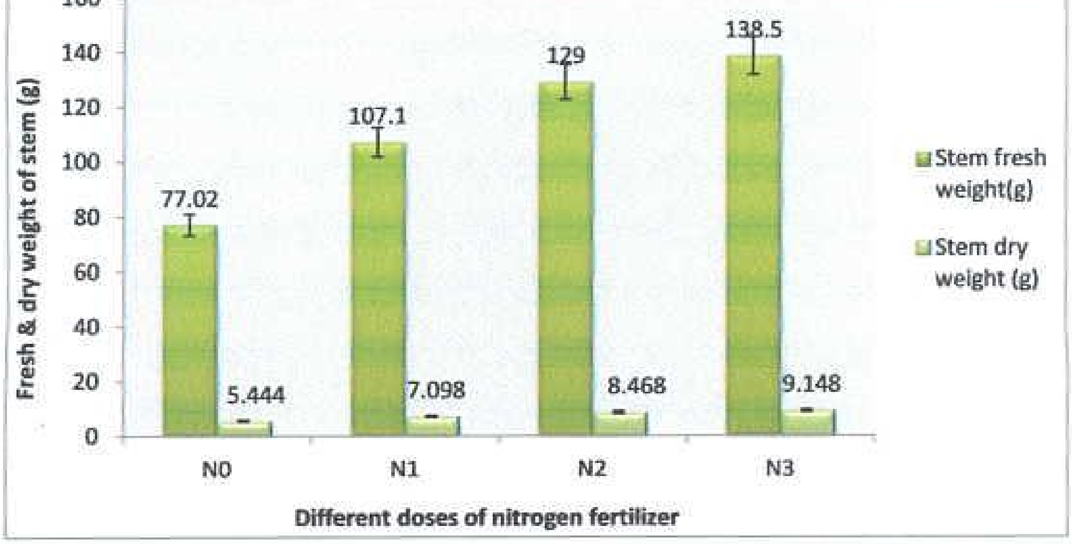
4.6 Fresh and dry weight of stem

4.6.1 Effect of urea

The effect of different nitrogen treatments on stem fresh weight (g) plant^{-1} of green amaranth was significant at harvest (Appendix VI). As shown in Figure 11, the highest fresh weight of stem (138.5 g) was measured in N_3 and that of lowest (77.02 g) was found in N_0 at harvest.

On the other hand, increase in nitrogen dose had a significant influence on the increase in stem dry weight too (Figure 11). Namely, a similar trend of highest (9.148 g) and lowest (5.444 g) dry weights were recorded in N_3 and N_0 treatments, respectively.

These sorts of findings indicated that increase in nitrogen doses had a positive effect on the increment of stem fresh and dry weight. In response to nitrogen fertilization, such patterns of fresh and dry stem weights for amaranths were reported by Miah *et al.* (2013) and Roy (2008).



Note: N_0 = 0 kg ha^{-1} (control), N_1 = 75 kg ha^{-1}, N_2 = 100 kg ha^{-1}, N_3= 125 kg ha^{-1}

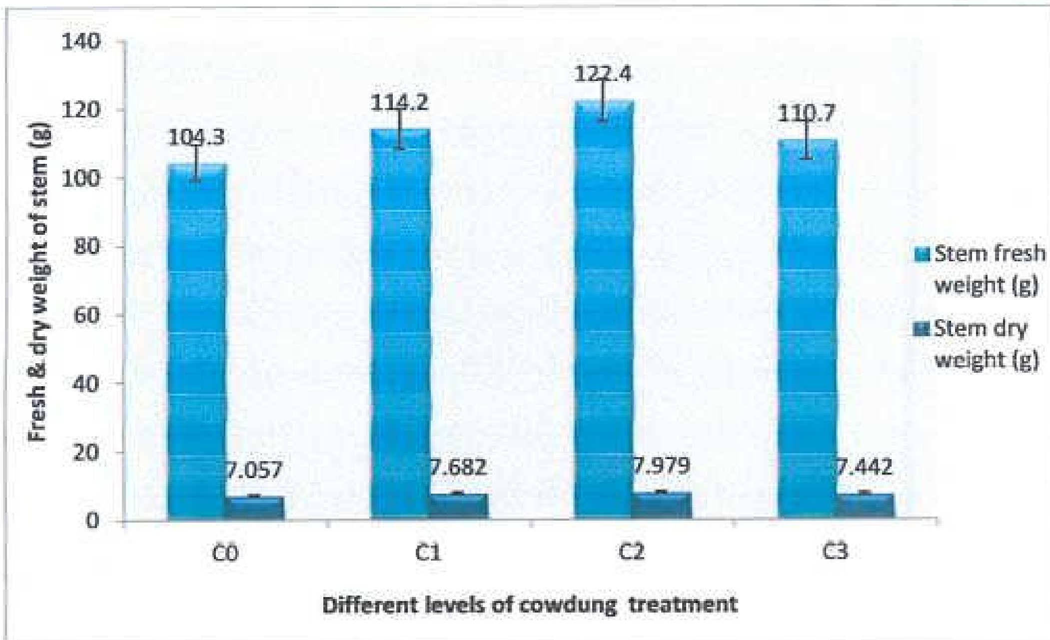
Figure 11. Effect of urea on fresh and dry weight of stem plant^{-1} of green amaranth after harvest

4.6.2 Effect of cow dung

The effect of different treatments of cow dung on stem fresh and dry weight (g) plant^{-1} of green amaranth was varied after harvest ((Figure 12 and Appendix VI). At harvest, the highest fresh weight of stem (122.4 g) plant^{-1} was measured in C_2 and that of lowest (104.3 g) was found in C_0.

Increase in cow dung dose had a significant influence on the increase in stem dry weight too (Figure 11). A similar trend of highest (7.979 g) and lowest (7.057 g) dry weights were recorded from C_2 and C_0 treatments, respectively.

With respect to fresh weight of individual plant and stem of green amaranth coincided with those reported by Rajgopal *et al.* (1977) and Hossain (1996). Addition of Cow dung or poultry manure enhanced plant height and fresh weight production of green amaranth (Fazal *et al.*, 2013).



Note: C_0 = 0 t ha^{-1} (control), C_1 = 2.5 t ha^{-1}, C_2 = 5 t ha^{-1}, C_3 = 7.5 t ha^{-1}

Figure 12. Effect of cow dung on fresh and dry weight of stem $plant^{-1}$ of green amaranth after harvest

4.6.3 Interaction effect of urea and cow dung

The variation was recorded due to combined effect of nitrogen and cow dung in terms of fresh weight of stem $plant^{-1}$ after harvest of green amaranth (Table 5). After harvest, the maximum (151.5 g) fresh weight of stem $plant^{-1}$ was obtained from N_3C_1 while N_0C_0 gave the minimum fresh weight of stem (67.73 g) $plant^{-1}$.

After oven dry, the maximum stem dry weight $plant^{-1}$ (9.793 g) was measured from the N_3C_1 treatment where the minimum stem dry weight $plant^{-1}$ (5.110 g) was measured from N_0C_0 treatment.

Oyedeji *et al.* (2014) and Fazal *et al.* (2013) suggested that cow dung and poultry manure appeared to be compatible to urea for stem amaranth cultivation in terms of fresh weight of stem which ultimately increase the production of green amaranth gross yield.

Table 5: Interaction effect of different doses of nitrogen fertilizer and cow dung on fresh and dry weight of leaves and stem plant^{-1} of green amaranth after harvest

Treatment		Leaves fresh weight(g) plant^{-1}	Leaves dry weight(g) plant^{-1}	Stem fresh weight(g) plant^{-1}	Stem dry weight(g) plant^{-1}
N_0	C_0	34.60 g	3.860 g	67.73 k	5.110 g
	C_1	36.40 fg	3.900 g	78.40 j	5.510 fg
	C_2	37.87 f	4.173 g	79.00 j	5.587 fg
	C_3	38.93 f	4.693 fg	82.93 i	5.570 fg
N_1	C_0	41.97 e	5.343 ef	97.67 h	6.243 f
	C_1	42.67 e	5.300 ef	103.5 g	7.350 e
	C_2	47.00 d	5.897 de	117.7 e	7.507 e
	C_3	45.57 d	5.653 def	109.5 f	7.293 e
N_2	C_0	47.07 d	6.177 cde	118.2 e	7.973 de
	C_1	50.40 c	6.213 bcde	123.3 d	8.073 de
	C_2	58.03 a	7.510 a	149.6 a	9.547 ab
	C_3	50.47 c	6.537 abcd	124.9 d	8.280 cde
N_3	C_0	55.20 b	7.050 abc	133.8 c	8.900 abcd
	C_1	59.80 a	7.320 ab	151.5 a	9.793 a
	C_2	55.27 b	7.150 abc	143.3 b	9.277 abc
	C_3	52.27 c	6.677 abcd	125.5 d	8.623 bcd
LSD $_{(0.05)}$		2.651	1.028	3.107	1.028
CV (%)		7.57	9.15	4.34	7.11
Level of significance		*	*	**	*

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 5% level of probability.

**, * - indicate significant at 1% and 5% level, respectively.

Note: N_0 = 0 kg ha^{-1} (control), N_1 = 75 kg ha^{-1}, N_2 = 100 kg ha^{-1}, N_3 = 125 kg ha^{-1}

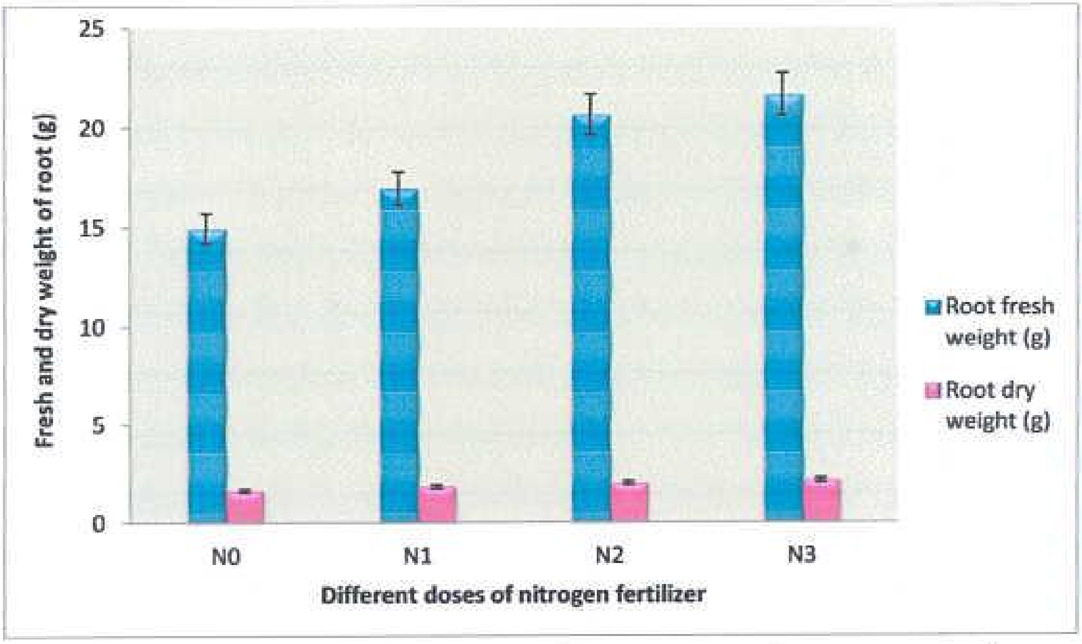
C_0 = 0 t ha^{-1} (control), C_1 = 2.5 t ha^{-1}, C_2 = 5 t ha^{-1}, C_3 = 7.5 t ha^{-1}

4.7 Fresh and dry weight of root

4.7.1 Effect of urea

There was significant effect of different nitrogen treatments on the production of fresh root weight (g) plant^{-1} of stem amaranth (Figure 13 and Appendix VII). As for fresh weight, the highest value (21.63 g) was observed in N_3 and that of the lowest (14.95 g) was recorded in N_0 and such pattern of fresh root weight production was similar to those of Talukder (1999).

In contrast, the trend of dry weight (g) of root production plant^{-1} was significant after oven dried. The highest dry root weight (2.141 g) was found from the N_3 treatment which was statistically similar to N_2 (2.001g) treatment and that of the lowest (1.631 g) was observed in N_0 treatment. The results were in contradiction with those of Miah *et al.* (2013) and Roy (2008) who stated that application of nitrogen was insignificant on the production of dry root weight of stem amaranth.



Note: N_0 = 0 kg ha^{-1} (control), N_1 = 75 kg ha^{-1}, N_2 = 100 kg ha^{-1}, N_3 = 125 kg ha^{-1}

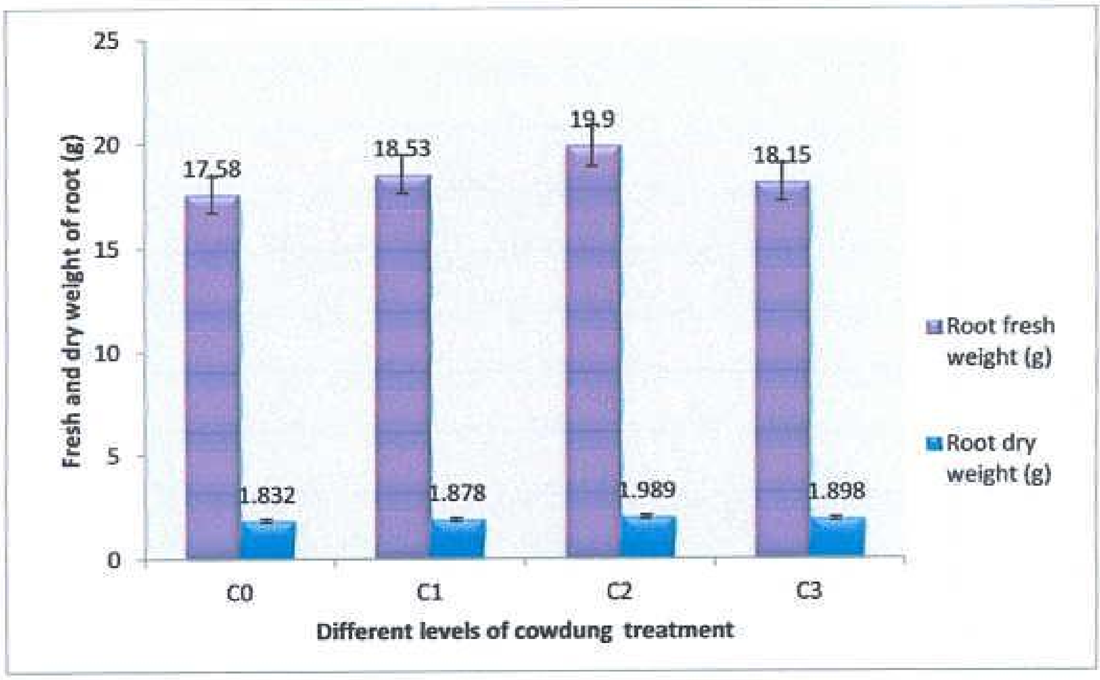
Figure 13. Effect of urea on fresh and dry weight of root plant^{-1} of green amaranth after harvest

4.7.2 Effect of cow dung

The variation was recorded due to single effect of cow dung in terms of fresh weight of root plant^{-1} after harvest of green amaranth (Figure 14 and Appendix VII). After harvest, the maximum (19.90 g) fresh weight of root plant^{-1} was obtained from C_2 while C_0 gave the minimum fresh weight of root (17.58 g) plant^{-1}.

The dry weight (g) of root production plant^{-1} was insignificant after oven dried. Numerically the highest dry root weight (1.989 g) was found from the C_2 treatment and that of the lowest (1.832 g) was observed in C_0 treatment.

But Akande (2006) concluded that organic substance has significant effect both on the fresh and dry weight of root plant^{-1}of green amaranth. Again, the results showed similar result with those of Miah *et al.* (2013) who stated that application of cow dung had no significant effect on the of dry root weight of stem amaranth but on fresh weight only.



Note: $C_0 = 0$ t ha^{-1} (control), $C_1 = 2.5$ t ha^{-1}, $C_2 = 5$ t ha^{-1}, $C_3 = 7.5$ t ha^{-1}

Figure 14. Effect of cow dung on fresh and dry weight of root plant^{-1} of green amaranth after harvest

4.7.3 Interaction effect of urea and cow dung

Significant influence was observed on the fresh and dry weight of root plant^{-1}of green amaranth due to the different interaction of nitrogen and cow dung after harvest and oven drying (Table 6). At harvest, the highest fresh weight of root plant^{-1} (25.20 g) was observed from the N_2C_2 treatment whereas the lowest fresh weight of root plant^{-1} (14.47 g) was observed from N_0C_0 treatment which was statistically similar to N_0C_1 (14.53 g).

After oven dried, the maximum root dry weight plant^{-1} (2.270 g) was measured from the N_3C_1 treatment which was statistically similar to N_2C_2 (2.263 g) where the minimum root dry weight plant^{-1} (1.493g) was measured from N_0C_0 treatment.

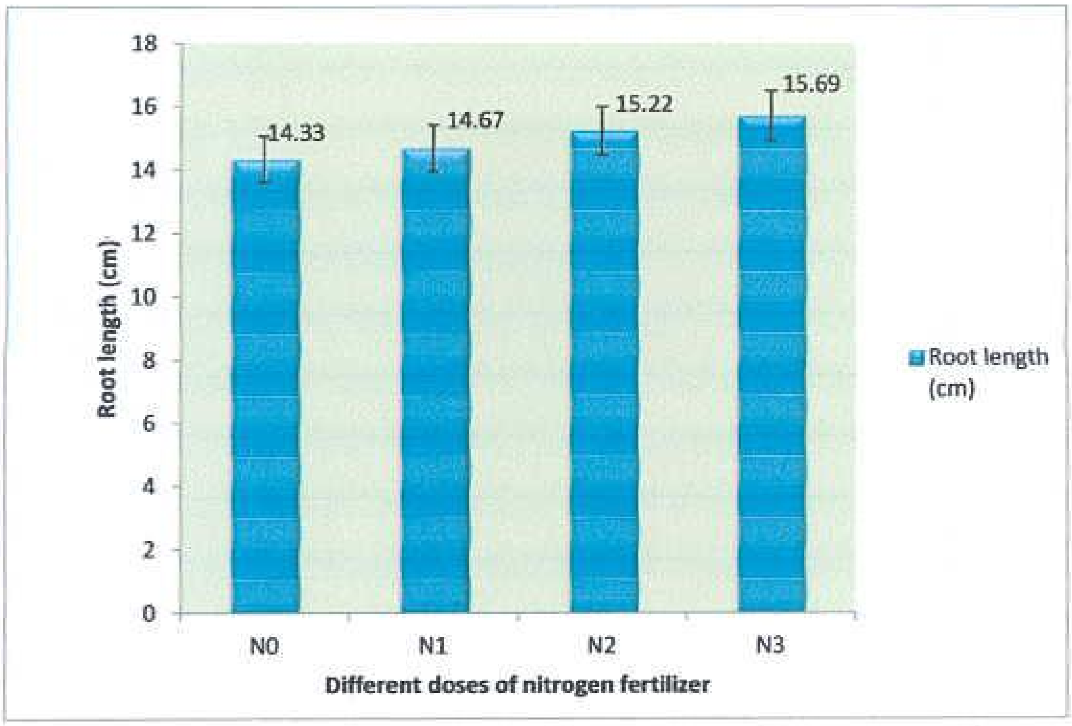
The plants treated with half-full rate of fertilizer plus half-full rate of organic fertilizer showed the highest value of root fineness and was observed to have a well developed tap root (Akande, 2006). This was follow by the plant that was treated with organic fertilizer alone, but in this case profuse and massive fine root growth that was observed. Also the tap root was not well developed (Fazal *et al.*, 2013).

4.8 Root length

4.8.1 Effect of urea

The effect of different nitrogen treatments on root length (cm) plant^{-1} of stem amaranth was significant (Figure 15 and appendix VII). The longest root length (15.69 cm) was found in treatment N_3 which was statistically similar to N_2 (15.22 cm) and the lowest (5.76 cm) was recorded in treatment N_0.

Miah *et al.* (2013) found contradictory results with this present study. But these sorts of effects of various nitrogen levels on root patterns of amaranths were reported by Roy (2008), Hossain (1996) and Talukder (1999).



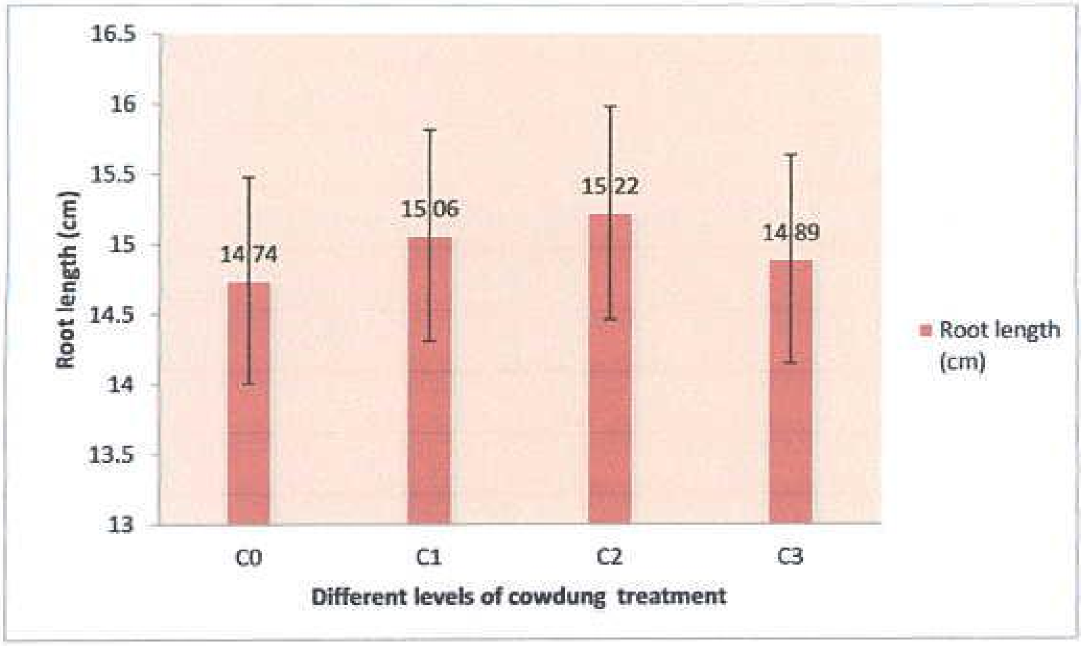
Note: N_0 = 0 kg ha^{-1} (control), N_1 = 75 kg ha^{-1}, N_2 = 100 kg ha^{-1}, N_3= 125 kg ha^{-1}

Figure 15. Effect of urea on length (cm) of root plant^{-1} of green amaranth after harvest

4.8.2 Effect of cow dung

The influence of cow dung treatments on root development i.e. root length (cm) plant^{-1} of green amaranth is presented on (Figure 16 and Appendix VII). The longest root length (15.22 cm) was found in treatment C_2 and the lowest (14.74 cm) was recorded in C_0 treatment.

Bongkyoon (2004) mentioned that the application of compost showed an increment in the average root length plant^{-1}.



Note: $C_0 = 0$ t ha^{-1} (control), $C_1 = 2.5$ t ha^{-1}, $C_2 = 5$ t ha^{-1}, $C_3 = 7.5$ t ha^{-1}

Figure 16. Effect of cow dung on length (cm) of root plant^{-1} of green amaranth after harvest

4.8.3 Interaction effect of urea and cow dung

In term of root length (cm) plant^{-1} of green amaranth, statistically, the interaction effect of nitrogen and cow dung treatments applied on root development gave significant difference (Table 6). The longest root length (16.55 cm) was found in treatment N_3C_1 and the lowest root length (14.21 cm) was recorded in N_0C_0 treatment.

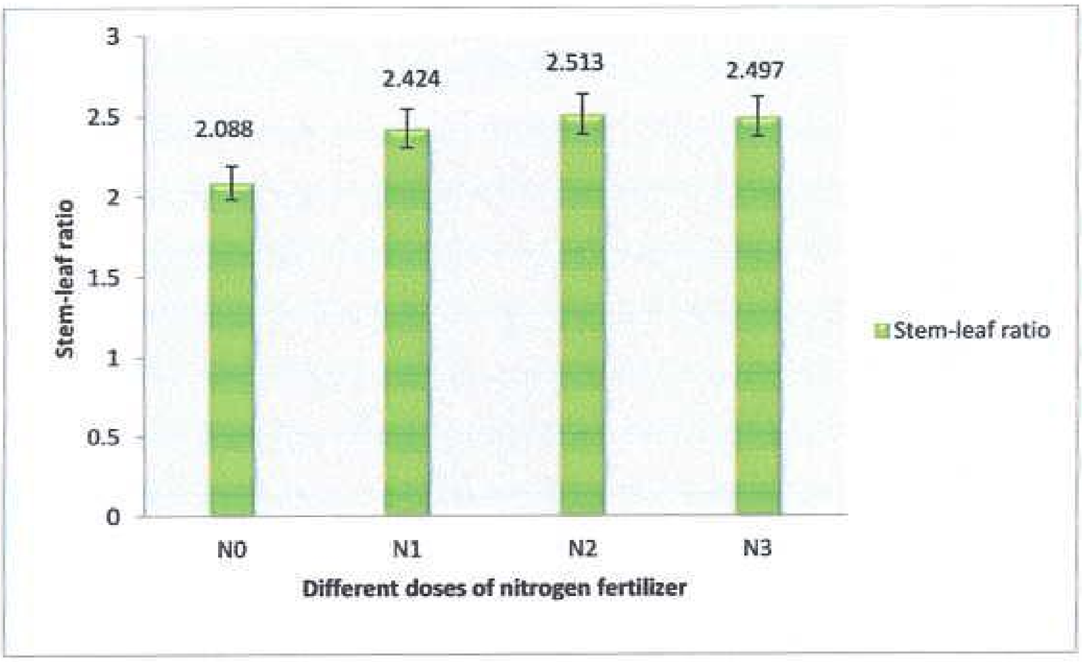
With respect to root length, Kabir (2007) observed that combine use of nitrogen and cow dung greatly affected the root length compared to cow dung alone while effect on control was the least. Akande (2006) found that the root fineness increase over ranges from 23 to 54%.

4.9 Stem-leaf ratio (on fresh weight basis)

4.9.1 Effect of urea

The stem-leaf ratio based on fresh weight basis plant^{-1} of stem amaranth was significantly influenced by different level of nitrogen application (Figure 17 and Appendix VII). After harvest, the maximum stem-leaf ratio (2.513) was measured from the N_2 treatment which was statistically similar to N_3 (2.497) whereas the lowest stem-leaf ratio (2.088) was measured from the N_0 treatment.

Arfin (2006) conducted an experiment to find out the influence of cultivar and nitrogen of amaranths and result showed that BARI Data-1 gave stem-leaf ratio varied from 1.83 t0 2.10. Mohidden *et al.* (1985) stated that the stem-leaf ratio was 2.00 in Co.3 amaranth. Campbell and Abbott (1982) also reported that stem-leaf ratio varied from 1.20 to 9.70 in twenty amaranth varieties. This present finding supports the previous observations.

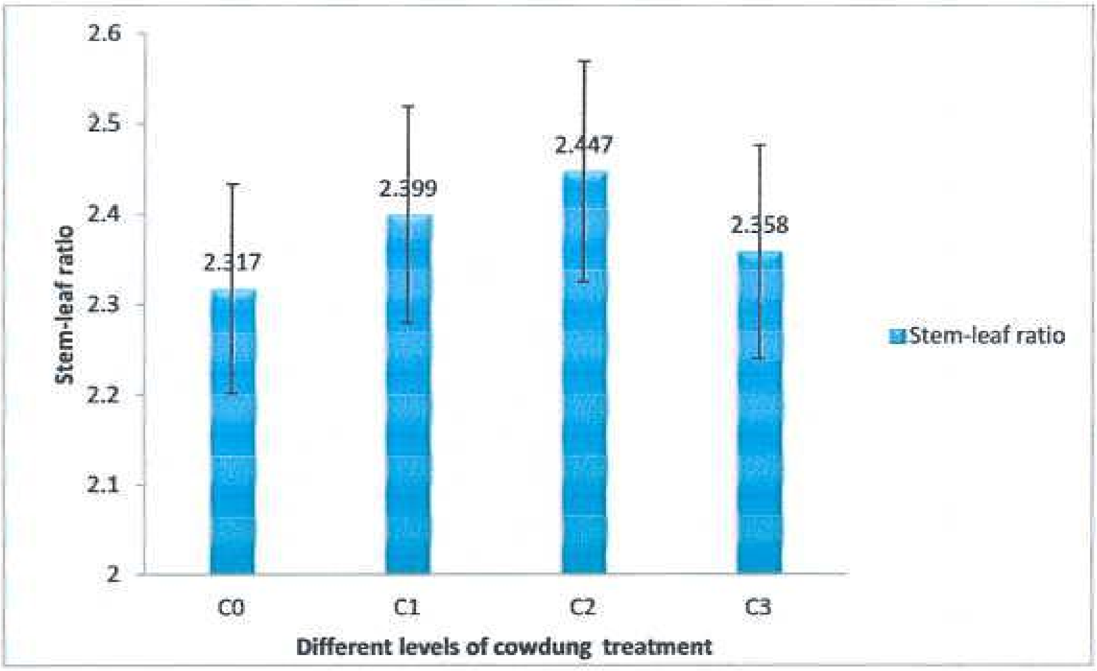


Note: N_0 = 0 kg ha^{-1} (control), N_1 = 75 kg ha^{-1}, N_2 = 100 kg ha^{-1}, N_3 = 125 kg ha^{-1}

Figure 17. Effect of urea on stem-leaf ratio (on fresh weight basis) of green amaranth after harvest

4.9.2 Effect of cow dung

A significant variation was recorded due to the different doses of cow dung for the stem-leaf ratio based on fresh weight basis plant^{-1} of stem amaranth (Figure 18 and Appendix VII). The maximum stem-leaf ratio based on fresh weight basis plant^{-1} of stem amaranth was 2.447 which recorded from the C_2 treatment and the lowest (2.317) was observed from the C_0 treatment. The results showed similar result with *those of* Miah *et al. (2013)*



Note: C_0 = 0 t ha^{-1} (control), C_1 = 2.5 t ha^{-1}, C_2 = 5 t ha^{-1}, C_3 = 7.5 t ha^{-1}

Figure 18. Effect of cow dung on stem-leaf ratio (on fresh weight basis) of green amaranth after harvest

4.9.3 Interaction effect of urea and cow dung

The interaction effect of different treatment of nitrogen and cow dung on stem leaf ratio was also significant (Table 6). The highest stem-leaf ratio (2.60) was recorded in treatment N_3C_2 which was statistically similar with N_2C_2 (2.58) and the lowest stem-leaf ratio (1.957) was recorded in N_0C_0 treatment.

So the result suggested that the treatments affect better growth over controlled to lead to such a remarkable stem-leaf ratio in control (Fazal *et al*., 2013).

Table 6: Interaction effect of different doses of nitrogen fertilizer and cow dung on different root parameters and stem-leaf ratio after harvest

Treatment		Root fresh weight(g)	Root dry weight(g)	Root length (cm)	Stem-leaf ratio
N_0	C_0	14.47 h	1.493 c	14.21 e	1.957 g
	C_1	14.53 h	1.593 bc	14.24 de	2.173 f
	C_2	15.00 gh	1.677 abc	14.46 cde	2.090 f
	C_3	15.80 fg	1.760 abc	14.40 de	2.133 f
N_1	C_0	16.33 f	1.840 abc	14.51 cde	2.333 e
	C_1	16.87 ef	1.733 abc	14.59 cde	2.433 cd
	C_2	16.73 ef	1.837 abc	14.75 cde	2.520 abc
	C_3	17.80 e	1.887 abc	14.83 cde	2.410 de
N_2	C_0	19.00 d	1.903 abc	14.85 cde	2.530 ab
	C_1	19.13 d	1.917 abc	14.86 cde	2.457 bcd
	C_2	25.20 a	2.263 a	16.07 ab	2.580 a
	C_3	19.27 d	1.920 abc	15.11 bcde	2.483 bcd
N_3	C_0	20.53 c	2.090 abc	15.39 bcd	2.447 bcd
	C_1	23.60 b	2.270 a	16.55 a	2.533 ab
	C_2	22.67 b	2.180 ab	15.61 abc	2.600 a
	C_3	19.73 cd	2.023 abc	15.22 bcde	2.407 de
LSD (0.05)		1.153	0.5841	1.045	0.0826
CV (%)		3.67	9.85	4.78	8.21
Level of significance		**	*	*	*

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 5% level of probability.

**, * - indicate significant at 1% and 5% level, respectively.

Note: N_0 = 0 kg ha^{-1} (control), N_1 = 75 kg ha^{-1}, N_2 = 100 kg ha^{-1}, N_3 = 125 kg ha^{-1}

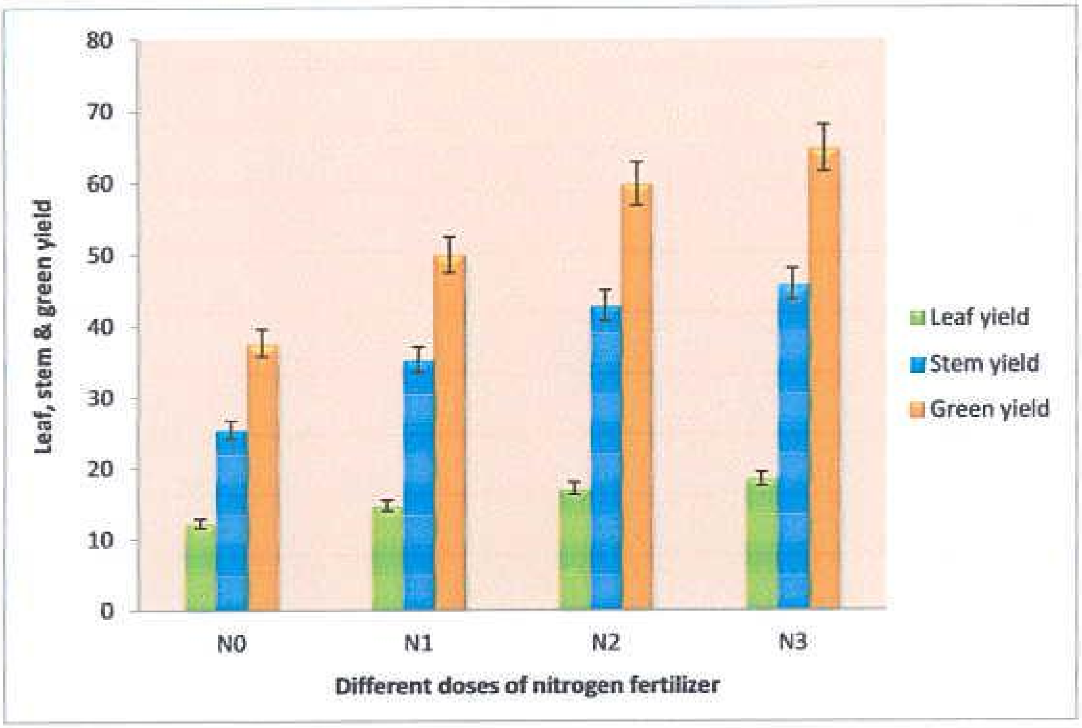
C_0 = 0 t ha^{-1} (control), C_1 = 2.5 t ha^{-1}, C_2 = 5 t ha^{-1}, C_3 = 7.5 t ha^{-1}

4.10 Leaf yield

4.10.1 Effect of urea

Leaf yield (t ha^{-1}) of green amaranth was positively influenced by various nitrogen treatments (Figure 19 and Appendix VIII). However, variation among the treatments corresponding to stem amaranth yield per hectare was significant. The highest yield (18.36 t ha^{-1}) was found in N_3 and the lowest yield (12.19 t ha^{-1}) was recorded in N_0.

Generalized trend observed for leaf yield (t ha^{-1}) increased with the increase in nitrogen dose. Olaniyi *et al.* (2008) suggested that increase in N rate increases cell size and cell number as a result of cell division and expansion leading to increased size and number of leaves and growth of other vegetative parts of the plant which increases yield ultimately. Rahman (2006) and Begum (2007) reported the similar result.



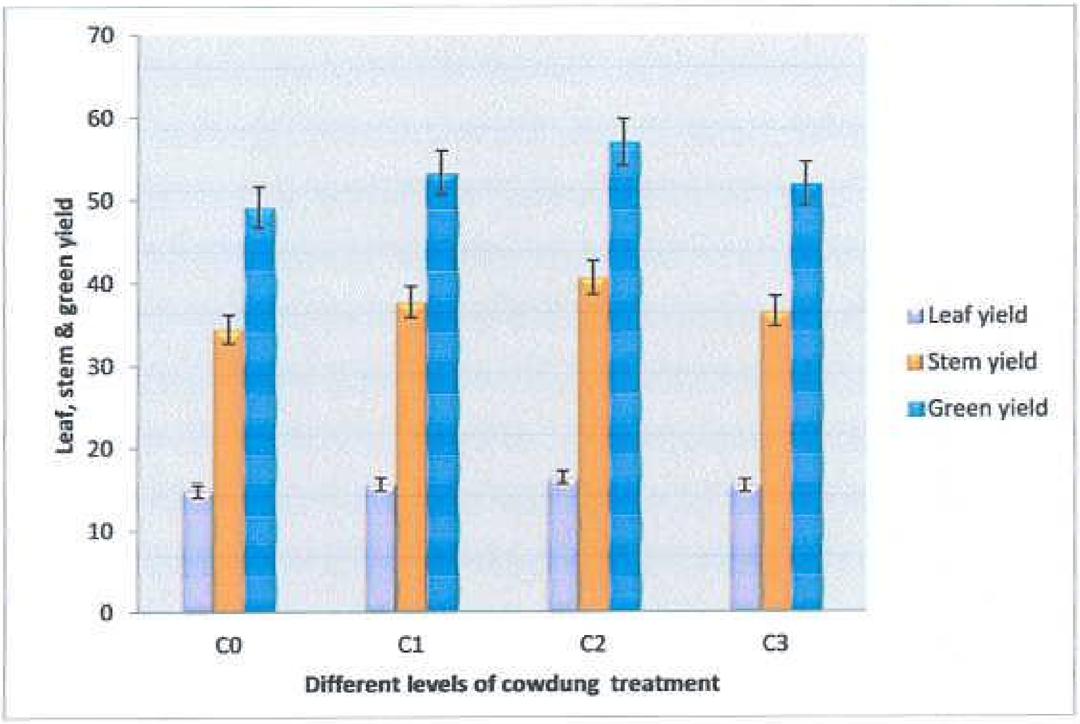
Note: $N_0 = 0$ kg ha^{-1} (control), $N_1 = 75$ kg ha^{-1}, $N_2 = 100$ kg ha^{-1}, $N_3 = 125$ kg ha^{-1}

Figure 19. Effect of urea on leaf, stem and green yield (t ha^{-1}) of green amaranth after harvest

4.10.2 Effect of cow dung

The leaf yield (t ha^{-1}) of green amaranth was significantly influenced by different level of cow dung application (Figure 20 and Appendix VIII). The result revealed that the C_2 treatment produced the maximum leaf yield (16.38 t ha^{-1}). The trend of leaf yield showed an increasing trend with the increased rate of cow dung. It is observed that the C_0 treatment gave the minimum leaf yield (14.75 t ha^{-1}).

These findings were supported by Fazal *et al.* (2013) and Rahman *et al.* (2012) who reported that leaf yield of amaranth increased with the increased rate of organic manure.



Note: $C_0 = 0$ t ha^{-1} (control), $C_1 = 2.5$ t ha^{-1}, $C_2 = 5$ t ha^{-1}, $C_3 = 7.5$ t ha^{-1}

Figure 20. Effect of cow dung on leaf, stem and green yield (t ha^{-1}) of green amaranth after harvest

4.10.3 Interaction effect of urea and cow dung

The variation was recorded due to the combined effect of nitrogen and cow dung in terms of leaf yield (t ha^{-1}) of green amaranth (Table 7). The highest yield (19.26 t ha^{-1}) was found in N_2C_2 and the lowest yield (11.42 t ha^{-1}) was recorded in N_0C_0 which was statistically identical with N_0C_1 (12.01 t ha^{-1}).

From the results it was noted that both nitrogen and cow dung favored growth of stem amaranth and the ultimate result was the highest yield (Akande, 2006 and Fazal *et al.*, 2013).

4.11 Stem yield

4.11.1 Effect of urea

Different nitrogen rates had significant effect on the stem yield (t ha^{-1}) of green amaranth (Figure 19 and Appendix VIII). The stem yield showed an increasing trend with the increases of nitrogen rate and the maximum stem yield (45.72 t ha^{-1}) was observed from the N_3 treatment whereas the minimum stem yield (25.41 t ha^{-1}) was observed from N_0 treatment.

Such results were in perfect agreement with those of Ara (2005), Rahman (2006) and Begum (2007). The positive effect of applied N rates on stem yield was also in agreement with the report of Olaniyi (2000) where NPK was effective in increasing final melon.

4.11.2 Effect of cow dung

Significant influence was observed on the stem yield (t ha^{-1}) of green amaranth due to different rates of cow dung application (Figure 20 and Appendix VIII). The maximum stem yield (40.63 t ha^{-1}) was recorded from the C_2 treatment whereas the lowest stem yield (34.44 t ha^{-1} was observed from the control or C_0 treatment.

Ahmed (2011), Fazal *et al.* (2013) and Kabir (2007) reported the similar result. They reported that deficiency of organic manure gave the lowest amaranth yield.

4.11.3 Interaction effect of urea and cow dung

In term of stem yield of amaranth, there was a significant interaction effect of nitrogen and cow dung observed after harvest (Table 7). The result reveals that the maximum stem yield (50.35 t ha^{-1}) was measured from the N_2C_2 treatment which was statistically similar with N_3C_1 (50.00 t ha^{-1}). However, the combination N_0C_0 gave the lowest stem yield (22.35 t ha^{-1}).

Fazal *et al.* (2013) and Akande (2006) conducted experiments and observed the interaction effect of nitrogen and cow dung which supports this finding. Akande (2006) stated that the stem yield increased from 13-41% because of proper nitrogen and cow dung application.

4.12 Green yield

4.12.1 Effect of urea

The green yield (t ha^{-1}) of stem amaranth showed significant variation due to application of different nitrogen treatments (Figure 19 and Appendix VIII). The results indicated that maximum yield (64.08 t ha^{-1}) was observed in the N_3 treatment and that of the lowest (37.61 t ha^{-1}) was recorded in the N_0 treatment.

These high and low yields could be ascribed for the highest nitrogen dose application followed by that received no nitrogen because N is central element for the growth and development of plant (Roy, 2008). Miah et al. (2013), Arfin (2006) and Rathore *et al.* (2004) also reported similar views that the yield of green amaranth increased with the increased rate of nitrogen fertilizer.

4.12.2 Effect of cow dung

The cow dung application showed significant influence on the green yield (t ha^{-1}) of green amaranth (Figure 20 and Appendix VIII). The highest green yield of green amaranth (57.01 t ha^{-1}) was obtained from C_2 and the lowest one (49.19 t ha^{-1}) was found from the C_0 treatment.

This result was in agreement with the finding of Kabir (2007), Ahmed *et al.* (2011) and Oyedeji *et al.* (2014) who reported that green yield performance varied with the application of cow dung variation.

4.12.3 Interaction effect of urea and cow dung

The green yield (t ha^{-1}) of green amaranth was significantly varied due to interaction effect of nitrogen and cow dung doses (Table 7). The highest green yield (69.74 t ha^{-1}) was recorded from the N_3C_1 treatment which was statistically similar with N_2C_2 (69.61 t ha^{-1}) whereas the lowest green yield (33.77 t ha^{-1}) was recorded from the treatment combination N_0C_0.

These results are in conformity with those of Islam *et al.* (2005) and Monira *et al.* (2007). Thus significant variations in stem diameter of green amaranth also lied in the suggestions of Rajgopal *et al.* (1977), Hossain (1996) and Talukder (1999).

Table 7: Interaction effect of different doses of nitrogen fertilizer and cow dung on different yield parameters after harvest

Treatment		Leaf yield (t ha^{-1})	Stem yield (t ha^{-1})	Green yield (t ha^{-1})
N_0	C_0	11.42 g	22.35 j	33.77 k
	C_1	12.01 g	25.87 i	37.89 j
	C_2	12.50 fg	26.07 i	38.56 ij
	C_3	12.85 fg	27.37 i	40.22 i
N_1	C_0	13.85 ef	32.23 h	46.08 h
	C_1	14.08 def	34.16 g	48.24 g
	C_2	15.51 cd	38.83 e	54.34 e
	C_3	15.04 cde	36.15 f	51.18 f
N_2	C_0	15.53 cd	39.00 e	54.54 e
	C_1	16.63 bc	40.70 de	57.33 d
	C_2	19.26 a	50.35 a	69.61 a
	C_3	16.66 bc	41.21 d	57.86 d
N_3	C_0	18.21 ab	44.15 c	62.37 c
	C_1	19.73 a	50.00 a	69.74 a
	C_2	18.24 ab	47.28 b	65.52 b
	C_3	17.25 b	41.42 d	58.67 d
$LSD_{(0.05)}$		1.523	1.791	2.032
CV (%)		7.6	4.35	3.95
Level of significance		*	**	**

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 5% level of probability.

**, * - indicate significant at 1% and 5% level, respectively.

Note: N_0 = 0 kg ha^{-1} (control), N_1 = 75 kg ha^{-1}, N_2 = 100 kg ha^{-1}, N_3 = 125 kg ha^{-1}

C_0 = 0 t ha^{-1} (control), C_1 = 2.5 t ha^{-1}, C_2 = 5 t ha^{-1}, C_3 = 7.5 t ha^{-1}

Chapter V

Summary and Conclusion

CHAPTER V
SUMMARY AND CONCLUSION

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University during the period from 12th April to 31st May, 2014 to find out the effect of urea as N source and cow dung application on the growth and yield of green amaranth cv. BARI Data-1. The experiment comprised of two factors was laid out in a Randomized Complete Block Design (RCBD) design with three replications. Factor A: four levels of nitrogen viz. N_0 (control), N_1 (75 kg N ha^{-1}), N_2 (100 kg N ha^{-1}) and N_3 (125 kg N ha^{-1}); and factor B: four levels of cow dung viz. C_0 (control), C_1 (2.5 t CD ha^{-1}), C_2 (5 t CD ha^{-1}) and C_3 (t CD ha^{-1}). The unit plot size was 3.5 m^2 (2.5 m x 1.4 m). There were 16 treatment combinations in the experiment. Each plot was fertilized with 25 kg P_2O_5 ha^{-1} as TSP and 50 kg K ha^{-1} as MOP. Urea as nitrogen source and cow dung was applied as per experimental treatments. Common cultural practices were adopted for each plot as and when required to ensure good growth of the crop. The data on different plant growth, yield and yield contributing characters were recorded.

Urea application affected all of the growth and yield parameters studied significantly. The level of nitrogen 125 kg ha^{-1} (N_3) gave highest plant height at 30, 40 DAS and at harvest but at 20 DAS 100 kg ha^{-1}(N_2) gave the highest height while the lowest was observed from N_0 treatment (Figure 1). The same trend was observed for N_3 treatment over N_0 in case of number of leaves, stem diameter and leaf greenness at all stages. The N_3 treatment gave the maximum leaves fresh and dry weight $plant^{-1}$, highest fresh and dry stem weight $plant^{-1}$ and highest root fresh and dry weight $plant^{-1}$ with maximum length of root when the lowest was found from the N_0 Though the N_2 treatment gave the maximum results for stem-leaf ratio recorded on the fresh weight basis. Significantly highest yield of leaf and stem i.e. maximum green yield were observed due to the application of 125 kg N ha^{-1} (N_3 treatment). The lowest result was obtained from N_0 treatment in all parameters.

Application of different levels cow dung had significant effect on growth and yield of BARI Data-1. At 30, 40 DAS and at harvest, the highest plant height was observed from the C_2 treatment (5 t CD ha^{-1}) except 20 DAS while the lowest was observed from C_0 treatment. At 20 and 30 DAS, the number of leaves plant^{-1} of green amaranth showed statistically insignificant variation among the cow dung doses. But numerically maximum number of leaves plant^{-1} was observed in the C_2 as well as the highest values observed at 40 DAS and harvest. In case of stem diameter, statistically insignificant results were shown at 20 DAS, but the C_2 treatment produced the highest number at all growth stages. Leaf greenness of green amaranth plant showed statistically significant variation at 30, 40 DAS and at harvest while C_0 gave the lowest result. The maximum fresh and dry weight of leaves plant^{-1}, the highest fresh and dry weight stem plant^{-1} including stem-leaf ratio and maximum fresh weight of root plant^{-1} were found from the C_2 treatment when the lowest was found from the C_0 treatment. The root dry weight showed statistically insignificant variation among the cow dung levels. But numerically maximum dry weight was observed in the C_2. The highest value of leaf yield, stem yield and green yield were observed from the C_2 treatment. The C_0 treatment showed the lowest influence in all cases.

All the parameters of green amaranth studied were showed significant influence by the interaction effect of urea and cow dung at all stages of observations except number of leaves plant^{-1} recorded at 30 DAS. From the interaction of nitrogen and cow dung, it was observed that the maximum plant height, number of leaves, stem diameter, leaf greenness, root length, fresh and dry weight of leaf, stem and root and maximum ratio of stem-leaf were observed either from the N_2C_2 combination or the N_3C_1 treatment. The same trend was observed either in the N_2C_2 or in the N_3C_1 over N_0C_0 in case of leaf yield, stem and green yield (Table 7). In most cases they showed statistically identical result. The lowest value of all parameters was observed in N_0C_0 treatment.

From the present study, it may be concluded that 125 kg N ha^{-1}was found the most effective treatment among the urea treatments. Application of 5 t cow dung ha^{-1} had the highest effect on yield than that of 2.5 t CD ha^{-1}. But the interaction of 100 kg N ha^{-1} and 5 t CD ha^{-1} performed better because of their favorable effect for improving yield of green amaranth and brings no harm to the environment.

However, farmers can perform the combination of urea and cow dung for yielding more amaranth. Further research is needed to find out the effect of other fertilizers and to draw a definite conclusion for recommendation. Such research is needed in Rabi season and in different agro-ecological zones (AEZs) of Bangladesh.

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Appendices

APPENDICES

Appendix I (a). Morphological characteristics of the experimental field

Morphology	Characteristics
Location	SAU Farm, Dhaka.
Agro-ecological zone	Madhupur Tract (AEZ- 28)
General Soil Type	Deep Red Brown Terrace Soil
Parent material	Madhupur Terrace.
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

(SAU Farm, Dhaka)

Appendix I(b). Initial physical and chemical characteristics of the soil

Characteristics	Value
Mechanical fractions:	
% Sand (2.0-0.02 mm)	22.26
% Silt (0.02-0.002 mm)	56.72
% Clay (<0.002 mm)	20.75
Textural class	Silt Loam
pH (1: 2.5 soil- water)	5.9
Organic Matter (%)	1.09
Total N (%)	0.028
Available K (ppm)	15.625
Available P (ppm)	7.988
Available S (ppm)	2.066

(SAU Farm, Dhaka)

Appendix II. Monthly average air temperature, relative humidity, rainfall and sunshine hours during the experimental period (April, 2014 to May, 2014) at Sher-e-Bangla Agricultural University

Month	Average air temperature (⁰ C)			Average relative humidity (%)	Total Rainfall (mm)	Total sunshine (hours)
	Maximum	Minimum	Mean			
April	33.2	25.81	29.51	79.10	351	229.30
May	33.44	26.29	29.87	80.78	680	215.12

(Bangladesh Meteorological Department, Climate Division, Agargaon, Dhaka– 1212)

Appendix III. Analysis of variance of the data on plant height of green amaranth as influenced by different levels of nitrogen and cow dung

Sources of variation	Degrees of freedom	Mean square values			
		Plant height (cm) plant^{-1}			
		20 DAS	30 DAS	40 DAS	At Harvest
Replication	2	4.073	37.503	29.661	45.911
Factor A (Nitrogen)	3	5.178*	201.471**	592.722**	554.794**
Factor B (Cow dung)	3	2.682^{NS}	13.749*	55.796**	15.092*
A X B	9	0.837*	4.844*	8.347*	11.349*
Error	30	14.32	19.238	14.642	17.238

**, * - indicate significant at 1% and 5% level, respectively
NS: Not significant

Appendix IV. Analysis of variance of the data on number of leaves of green amaranth as influenced by different levels of nitrogen and cow dung

Sources of variation	Degrees of freedom	Mean square values			
		Number of leaves plant^{-1}			
		20 DAS	30 DAS	40 DAS	At Harvest
Replication	2	9.963	4.266	0.621	0.353
Factor A (Nitrogen)	3	5.055*	10.807**	23.883**	66.373**
Factor B (Cow dung)	3	1.107^{NS}	1.178^{NS}	2.505*	4.222**
A X B	9	0.699*	0.336*	1.245*	1.399*
Error	30	1.858	2.029	1.239	0.979

**, * - indicate significant at 1% and 5% level, respectively.
NS: Not significant

Appendix V. Analysis of variance of the data on stem diameter (mm) and leaf greenness of green amaranth as influenced by different levels of nitrogen and cow dung

Sources of variation	Degrees of freedom	Mean square values					
		Stem diameter (mm) plant^{-1}			Leaf greenness		
		30 DAS	40 DAS	At Harvest	30 DAS	40 DAS	At Harvest
Replication	2	4.746	0.512	34.422	2.786	3.118	0.589
Factor A (Nitrogen)	3	5.083**	7.492**	19.460**	225.633**	388.397**	579.648**
Factor B (Cow dung)	3	0.424^{NS}	0.493*	1.328*	14.804**	18.595**	22.811**
A X B	9	0.279*	0.220*	0.551*	7.136**	6.037**	5.720**
Error	30	0.238	0.375	0.503	1.414	0.738	1.924

**, * - indicate significant at 1% and 5% level, respectively.
NS: Not significant

Appendix VI. Analysis of variance of the data on fresh and dry weight of leaves and stem plant^{-1} of green amaranth as influenced by different levels of nitrogen and cow dung

Sources of variation	Degrees of freedom	Mean square values			
		Leaves fresh weight(g) plant^{-1}	Leaves dry weight(g) plant^{-1}	Stem fresh weight(g) plant^{-1}	Stem dry weight(g) plant^{-1}
Replication	2	7.381	0.376	13.922	0.191
Factor A (Nitrogen)	3	811.867**	19.890**	8950.123**	32.145**
Factor B (Cow dung)	3	47.255**	0.794*	677.970**	1.825**
A X B	9	24.662*	0.422*	213.784**	0.565*
Error	30	12.714	0.285	24.036	0.288

**, * - *indicate significant at 1% and 5% level, respectively.*

Appendix VII. Analysis of variance of the data on fresh and dry weight with length of root plant^{-1}and stem-leaf ratio of green amaranth as influenced by different levels of nitrogen and cow dung

Sources of variation	Degrees of freedom	Mean square values			
		Root fresh weight(g) plant^{-1}	Root dry weight(g) plant^{-1}	Root length (cm) plant^{-1}	Stem-leaf ratio (on fresh weight basis)
Replication	2	0.385	0.021	0.007	0.016
Factor A (Nitrogen)		117.961**	0.585**	4.356**	0.473**
Factor B (Cow dung)	3	11.668**	0.052^{NS}	0.519*	0.038*
A X B	9	9.338**	0.042*	0.549*	0.013*
Error	30	0.464	0.035	0.513	0.038

**, * - *indicate significant at 1% and 5% level, respectively.*

NS: Not significant

Appendix VIII. Analysis of variance of the data on leaf, stem and green yield ($t\ ha^{-1}$) of green amaranth as influenced by different levels of nitrogen and cow dung

Sources of variation	Degrees of freedom	Mean square values		
		Leaf yield ($t\ ha^{-1}$)	Stem yield ($t\ ha^{-1}$)	Green yield ($t\ ha^{-1}$)
Replication	2	0.836	1.631	4.627
Factor A (Nitrogen)	3	88.713**	985.235**	1661.753**
Factor B (Cow dung)	3	5.325**	80.122**	126.486**
A X B	9	2.785*	25.873**	44.880**
Error	30	1.397	2.632	4.356

**, * - indicate significant at 1% and 5% level, respectively.