EFFECT OF NITROGEN AND PHOSPHORUS ON THE GROWTH AND YIELD OF STEM AMARANTH (*Amaranthus viridus*)

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CERTIFICATE

This is to certify that the thesis entitled, "EFFECT OF NITROGEN AND PHOSPHORUS ON THE GROWTH AND YIELD OF STEM AMARANTH" submitted to the Faculty of **AGRICULTURE**, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE** embodies the result of a piece of bona fide research work carried out by **AKLIMA RAHMAN, Registration No. 26218/00509** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated :

Dhaka, Bangladesh

(Md. Hasanuzzaman Akand)
Assistant professor
Supervisor

Dedicated to
my
beloved parents

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ABSTRACT

A field experiment was conducted in the experimental field and Horticulture laboratory of Sher-e Bangla Agricultural University, Dhaka, Bangladesh during the period from March 2006 to July 2006 to study the effect of different levels of nitrogen and phosphorous on the growth and yield of stem amaranth. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The experiment considered of two factors. Factor A: 4 Levels of Nitrogen (N) i.e. N_0 (no Nitrogen /Control), N_1 (92 kg N/ha), N_2 (96.6 kg N/ha) and N_3 (101.2 kg N/ha) ; Factor B: 4 Levels of Phosphorus (P_2O_5) i.e. P_0 (no Phosphorus/Control), P_1 (48 kg/ha), P_2 (52.8 kg/ha), P_3 (57.6 kg/ha). There were altogether 16 (4×4) treatment combinations. A significant variation was observed in respect of all characters at different days after sowing (DAS) in relation with different levels of nitrogen and phosphorous application. The maximum yield and yield contributing characters were observed from N_3 and the minimum was found from control treatment at all DAS. The maximum plant height (88.82 cm) was recorded at harvest (55 DAS) from N_3 while the minimum (76.01 cm) was found from control. The maximum (23.76 mm) stem diameter and green yield (76.47 t/ha) was obtained from N_3 at harvest (55 DAS). Significant variation was also observed in different days after sowing with the application of phosphorus. The maximum (85.40 cm) plant height, stem diameter (22.22 mm) and green yield (67.99 t/ha) recorded from where the plants received 57.6 kg P_2O_5/ha and minimum was performed in control at harvest (55 DAS). The maximum (83.32 t/ha) yield was found from the combination of N_3P_3 and the minimum (34.86 t/ha) was recorded from control (N_0P_0). In the combination of different doses of Nitrogen and phosphorous the highest benefit cost ratio (1.92) was attained from the treatment combination of N_3P_3 and lowest befit cost ratio (0.31) was obtained from N_0P_0 (control).

ACRONYMS

/	=	Per	DAS	=	Days After Sowing
CV.	=	Coefficient of variance	BBS	=	Bangladesh Bureau of Statistics
BCR	=	Benefit Cost Ratio	BAU	=	Bangladesh Agricultural University
Fig.	=	Figure	*et al.*	=	And others (at elli)
MP	=	Muriate of potash	S.A.U	=	Sher-e-Bangla Agricultural University
i.e.		That is	mm	=	Milimeter
N	=	Nitrogen	P_2O_5		Phosphorus penta oxide

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CHAPTER I

Introduction

INTRODUCTION

Amaranth (*Amaranthus viridus*) belongs to the genus *Amaranthus* and the family Amaranthaceae. Amaranth grown mainly during summer and rainy season are important popular vegetables in Bangladesh for its quick and vigorous growth and higher yield potential. It is widely grown as a green vegetable in tropical and subtropical parts of Asia, Africa and Central America (Hardwood, 1980). Amaranth is considered as a potential up coming 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) stated that the yield produces per month up to 30 t/ha of fresh matter. Consequently, amaranth may be harvested over a considerable period of time. 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. Amaranth is fairly rich in vitamin A, ascorbic acid and contains appreciable amounts of iron, calcium, phosphorous, riboflavin, thiamine, niacin and iron (Thompson and Kelly, 1988).

At present amaranth is being cultivated in an area of 6547 hectare of Bangladesh with a total production of 32585 metric tonnes of green amaranth (BBS, 2004). The average yield is only 4.98 t/ha, which is much lower as compared to other amaranth growing countries. To attaining considerable production and quality yield for any crop it is necessary to proper management including ensuring the availability of essential nutrient components. Amaranth thrives well in a fertile, clay loam soil because it requires considerable amounts of nutrients to sustain rapid growth in short time. But in our country most of the amaranth growers cultivate this crop in fallow land without following any management practices. In every case they cultivate this crop without any management practices especially without any organic or inorganic manure. But some cases they apply only some organic manure.

Amaranth responds greatly to major essential elements like N, P and K in respect of its growth and yield (Mital *et al.*, 1975; Singh *et al.*, 1976; Thompson and Kelly, 1988). Its production can be increased by adopting improved cultural practices. Among them proper fertilizer management are important. Generally, chemical fertilizer increased the growth and yield but excessive application of chemical fertilizers in crop production causes health hazards, create problem to the environment including the pollution of soil, air and water. This practice also increase the production cost of the specific crop.

But a large amount of nitrogen is required for the growth of the leaf and stem of amaranth (Opena *et al.*, 1988). Nitrogen has profound effect on the progressively increases the marketable yield (Obreza and Vavrina, 1993). It plays a vital role as a constituent of protein, nucleic acid and chlorophyll. 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., 1972). An adequate supply of nitrogen is essential for vegetative growth, and desirable yield (Yoshizawa *et al.*, 1981). Excessive application of nitrogen on the other hand is not only uneconomical, but it can prolong the growing period and delay crop maturity. On the contrary, excess nitrogen application induces physiological disorder that causes small black spots on the midribs of leaves.

Phosphorus is also one of the important essential macro elements for the growth and development of plant. The phosphorus requirements vary depending upon the nutrient content of the soil (Bose and Som, 1986). Considering as a leafy vegetable lack of phosphorus restricted the plant growth and remains immature (Hossain, 1990). Amaranth is as a vegetable with short duration crops, for that easily soluble fertilizer like as phosphorus should be applied in the field. On the other hand nutrient availability in a soil depends on some factor among them balance fertilizer is the important one. The optimum proportion of nitrogen and phosphorus fertilizer enhances the growth and development of a crop as well as ensuring the availability of other essential nutrients for the plant. Again secondary mechanism of interference was the absorption of phosphorus from the soil through luxury consumption, increasing the tissue content without enhancing smooth biomass accumulation (Santos *et al.*, 2004).

Considering the above circumstances, the present investigation has been undertaken with the following objectives:

1. To determine the optimum dose of nitrogen and phosphorus fertilizer for growth and yield of stem amaranth.
2. To find out the combined effect of nitrogen and phosphorus fertilizer for yield.
3. To find the cost of production by the application of different levels of fertilizers.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Amaranth is one of the important summer vegetable in Bangladesh and as well as many countries of the world. The crop has conventional less concentration by the researchers on various aspects because normally it grows without less care or management practices. For that a very few studies on the related to growth, yield and development of amaranth have been carried out in our country as well as many other countries of the world. So the research work so far done in Bangladesh and is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings related to the nitrogenous and phosphorous fertilizer so far been done at home and abroad on this crop have been reviewed in this chapter under the following headings

2.1 Effect of nitrogen on the growth and yield

Subhan (1989) conducted a field experiment at Lembang from August to September 1988 to find out the effect of doses and application time of nitrogen fertilizer on growth and yield of amaranth with N @ 0, 30, 70 and 110 kg/ha was 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.

In small plot trails on dernopodzolic soil in the mountain region with 0, 60 or 120 kg/ha 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/plant at all growth stages. Fresh matter yield increased from 29.9-31.2 t/ha 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 on study the effects of nitrogen fertilizer rates on yield and yield components of two amaranth cultivars in 1995 in Samsun, Turkey, with 0, 3, 6, 9 or 12 kg N/ha/day. From the results reported that there were no significant effects 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.

In a field experiment during summer 1990/1991 and 1991/92 at Kinnaur, Himachal Pradesh, India by Saini and Shekhar (1998) to find out the effect of nitrogen fertilizer on growth and yield of amaranth were given 0, 30, 60, 90 and 120 kg N/ha and reported that yield and most yield components increased significantly upto 90 kg N/ha, then decreased.

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 N/ha in Kalyani, India. From their experiment they reported that yield components and seed yield increased with increasing N upto 120 kg N/ha.

Seeds of amaranth (*Amaranthus* spp.) cultivated under 8 N levels (0, 50, 100, 150, 200, 250, 300, 350 and 400 kg/ha) were evaluated for protein content, protein yield per hectare and some starch characteristics by Hevia *et al*. (2000). The protein content fluctuated 6.5% (at 0 kg N/ha) and 18.4% (200 kg N/ha). The protein yield per hectare fluctuated between 457.2 (at 0 kg N/ha) and 973.4 kg/ha (at 300 kg N/ha), 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.

Ayodele *et al*. (2002) conducted a field experiment to evaluate the effect of N fertilizer @ 0, 50, 100 and 200 kg/ha on growth and yield of amaranth. Results showed that 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 increased leaf production upto 75%, on the other hand yield increases upto 114% in the application of 200 kg N/ha. The unfertilized plants also had yellowish green coloration compared to the brighter green color observed in fertilized plants.

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.

Yung *et al*. (2003) conducted a field experiments in Wufeng, Taiwan, to measure canopy reflectance spectra and plant characters of amaranth grown during 2001-2002. Simple linear correlation analysis between plant characters and canopy spectral reflectance existed along the measured spectral bands. The results suggested that plant growth and nitrogen status of vegetable amaranth may be estimated by regression models from canopy spectral characteristics.

Green amaranth cultivar was supplied with 0, 30, 60 and 90 kg N/ha 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. In 90 kg/ha 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.

2.2 Effect of phosphorus on the growth and yield

Shrefler *et al*. (1994) conducted a field studies at Belle lade, Florida to determine the influence of phosphorus fertility and method of application on the competitive interaction of amaranth. Duration of interference had little or no effect on P content and interspecific competition between the species probably was not due to competition for P but some other factor.

Efficiency indexes associated with growth assimilate partitioning and P utilization was studied to evaluate the ability of amaranth to recover from P deficiency by Blanco and Ascencio (2001). Pot grown plants were irrigated either with a nutrient solution containing adequate P from 16 to 32 days after sowing or with a nutrient solution deficient in P from 16 to 23 DAS followed by a nutrient solution sufficient in P from 24 to 36 DAS. P deficiency reduced dry matter accumulation by 70%, total leaf area by 60%, leaf number by 39%, and total relative growth rate by 36%. P deficiency also reduced leaf sucrose content by almost 100%. The recovery of plants from P deficiency was followed by in increase in sucrose concentrations. The results indicated that amaranth exhibited high potential for recovery from P deficiency.

Santos *et al.* (2003) carried out a field trails in South Florida, United States, between 1996 and 1999 to determine the extent of yield reductions under two P fertility regimes. Phosphorus was applied in two ways likely broadcast at 250 kg P/ha and banded at 125 kg/ha. When P was broadcasted, yield reductions were observed approximately 20% in no weeding condition whereas 24% reductions were occurred in banded condition. Maximum yield was recorded from 250 kg P/ha treatment. On another experiment Dusky *et al.* (1996) conducted an experiment to find out the influence of phosphorus fertility in greenhouse and field condition during 1992-1993 and reported that yield was affected by phosphorus fertility and its application method.

Rana and Rameshwar (2003) conducted an experiment in Sangla, Kinnaur, Himachal Pradesh, India during the summer seasons of 2000 and 2001 to find out the response to phosphorus fertilizer at 20, 40 and 60 P_2O_5 kg/ha rate under irrigated conditions on amaranth. Yield and yield contributing characters increased significantly with the increase in the rate of fertilizer. But maximum net returns and benefit cost ratio were obtained from the phosphorous fertilizer application @ 40 kg P_2O_5 per hectare under irrigated conditions.

A field trails were conducted to investigate the influence of P application method on the critical period of amaranth by Santos *et al.* (2004) with phosphorus fertilizer at rates of 125 or 250 kg/ha, respectively. Significant differences in respect of marketable yield, fresh yield and stem diameter were recorded at harvest. Fresh yield was 20% higher in 250 kg ha^{-1} compare with 125 kg/ha P in the method of broadcasting application.

Santos *et al.* (2004) conducted a greenhouse studies to determine the influence of phosphorus concentrations on the growth of amaranth and P-absorption rate over time. For the P-competition studies mixtures were established in P-less hydroponics solutions. No biomass changes were observed in amaranth as P concentration increased. From this experiment it was recorded that the plant absorbed P luxuriously.

2.3 Combined effect of nitrogen and phosphorus on the growth and yield

Panda *et al.* (1991) carried out a field experiment during 1989-90 on amaranth growing on acid lateritic soils with N applied at 0, 20, 40 or 60 kg/ha and P_2O_5 and K_2O applied at 0 or 20 kg/ha. P_2O_5 and K_2O were applied as a basal dose at sowing time with N applied either as a full basal dose or 50% basal and 50% as a foliar spray. Highest fresh yield (12.7 t/ha) and protein content (4.9 g/100 g) were obtained with 60 kg N+20 kg P_2O_5+20 kg K_2O/ha with N applied as a full basal dose. The same treatment but with N applied as 50% basal + 50% foliar spray resulted in the next highest yield and protein content.

Chakhatrakan *et al.* (1994) conducted a field experiment to study the effect of nitrogen and phosphatic fertilizer application on growth and yield of amaranth with 8 kg of N, P and K kg/10 acres or 16 kg N+8 kg each of P and K or 16 kg P=8 kg each of N and K. Shoot dry matter yield was highest in both species where P rate was doubled. Yields in were highest when P and N rates were doubled, respectively.

Jaishree *et al.* (1996) carried out a field experiment during the Kharif season of 1991 at Akola, Maharashtra to find out the effect of nitrogen and phosphate on yield and quality of amaranth which was grown at 0, 25 or 50 kg N and 0, 20 or 40 kg P_2O_5/ha. Seed yield was highest with 25 kg N and 40 kg P_2O_5. Seed N and crude protein content were increased by N and P applications.

A field experiment in 1985-87 at Brahmvar, Karnataka carried out by Lingaiah *et al.* (1997) on response of fertilizers on yield of fertilizer in coastal area with 6 local amaranth cultivars were given 50:25:25 kg NPK/ha and found that yield increased with increasing rate of fertilizer comparative to the control condition.

In a field experiment in 1991-1993 at Lucknow, Uttar Pradesh was carried out by Tewari and Misra (1997) on response of amaranth to nitrogen and phosphorus in sodic soils of UP with 0, 60 and 90 kg N and 0, 25 and 50 kg P/ha. Grain yield was highest with 90 kg N (1.40 and 1.33 t/ha in 1992 and 1993, respectively) and increased with up to 25 kg phosphorus.

Barik and Khanda (1999) conducted an experiment on response of amaranth to nitrogen and phosphorus with 0, 20, 40 and 60 kg N/ha and 0, 20, 40 kg P_2O_5/ha and found that yield would increased with increasing fertilizer upto maximum.

Thapa and Maity (2002) carried out a field experiment in the sandy loan of West Bengal, India during the summer seasons of 1998 and 1999 to study the effect of different N @ 50, 100 and 150 kg/ha and P_2O_5 @ 40 and 60 kg/ha 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 and 112.47 q/ha was obtained from treatments with N at 150, P_2O_5 at 60 kg/ha, respectively.

Effect of a compound NPK mineral fertilizer on the growth response of amaranths resulting from inorganic nutrient sources was investigated by Agele *et al*. (2004) in under sandy clay loam soil condition. The application rate of N 150 kg/ha from NPK fertilizer result the highest maximum yield as well as economic return. A higher proportion of the N present appeared to be resistant to microbial degradation and was thus unavailable for plant uptake.

CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

A field experiment was conducted in the experimental field of Sher-e Bangla Agricultural University, Dhaka, Bangladesh during the period from March 2006 to July 2006 to find out the effect of different levels of nitrogen and phosphorus fertilizer on the growth and yield of amaranth. The materials and methods for conducted for the experiment are presented in this chapter under the following headings

3.1 Experimental Site

The present experiment was conducted at the central farm and Horticulture Laboratory of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the experimental site is situated in $23^0 74'$N latitude and $90^0 35'$E longitude and an elevation of 8.2 meter from sea level (Anon, 1989).

3.2 Characteristics of Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ 28 and was non-calcarious dark grey. The selected land was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the SRDI, Soil testing Laboratory, Khamarbari, Dhaka and details of the recorded soil characteristics are presented in Appendix I.

3.3 Weather Condition of the Experimental Site

The geographical situation of the experimental site was under the subtropical climate, characterized by three distinct seasons, the monsoon or the rainy season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Details of the metrological data related to the temperature, relative humidity, rainfalls and sunshine during the period of the experiment was collected from the Bangladesh Meteorological Department (Climate Division), Dhaka and presented in Appendix II.

3 .4 Planting Materials

The variety name of Amaranth used in the experiment was "Baspata". It is a green stem and leafy type quick growing short duration summer vegetable. Seeds were collected from the sell centre of Bangladesh Agricultural Development Corporation (BADC). Seeds were sown with maintaining distance row to row 25 cm and plant to plant 20 cm.

3.5 Treatment of the Experiment

The experiment considered two factors. Details are presented below:

Factor A: Levels of nitrogen (4 levels)

i. N_0: No nitrogen (Control)

ii. N_1: 92 kg N/ha (used as urea 200 kg/ha)

iii. N_2: 96.6kg N/ha (used as urea 210 kg/ha)

iv. N_3: 101.2 kg N/ha (used as urea 220 kg/ha)

Factor B: Levels of phosphorus (4 levels)

i. P_0: No P_2O_5 (Control)

ii.P_1: 48 kg P_2O_5 /ha (used as TSP 100 kg/ha)

iii.P_2: 52.8kg P_2O_5 /ha (used as TSP 110 kg/ha

iv.P_3:57.6 kg P_2O_5 /ha (used as TSP 120kg/ha)

There were 16 (4 × 4) treatments combinations such as N_0P_0, N_0P_1, N_0P_2, N_0P_3, N_1P_0, N_1P_1, N_1P_2, N_1P_3, N_2P_0, N_2P_1, N_2P_2, N_2P_3, N_3P_0, N_3P_1, N_3P_2 and N_3P_3.

3.6 Layout of the Experiment

The two factors experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. An area of 33.5 m × 10 m was divided into three equal blocks. The layout of the experiment was prepared for distributing the treatment combinations into the each plot of each block. 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 plot was 2.0 m × 1.5 m. The distance maintained between two blocks and two plots were kept 1.0 m and 0.5 m respectively. The layout of the experiment is shown in Figure 1.

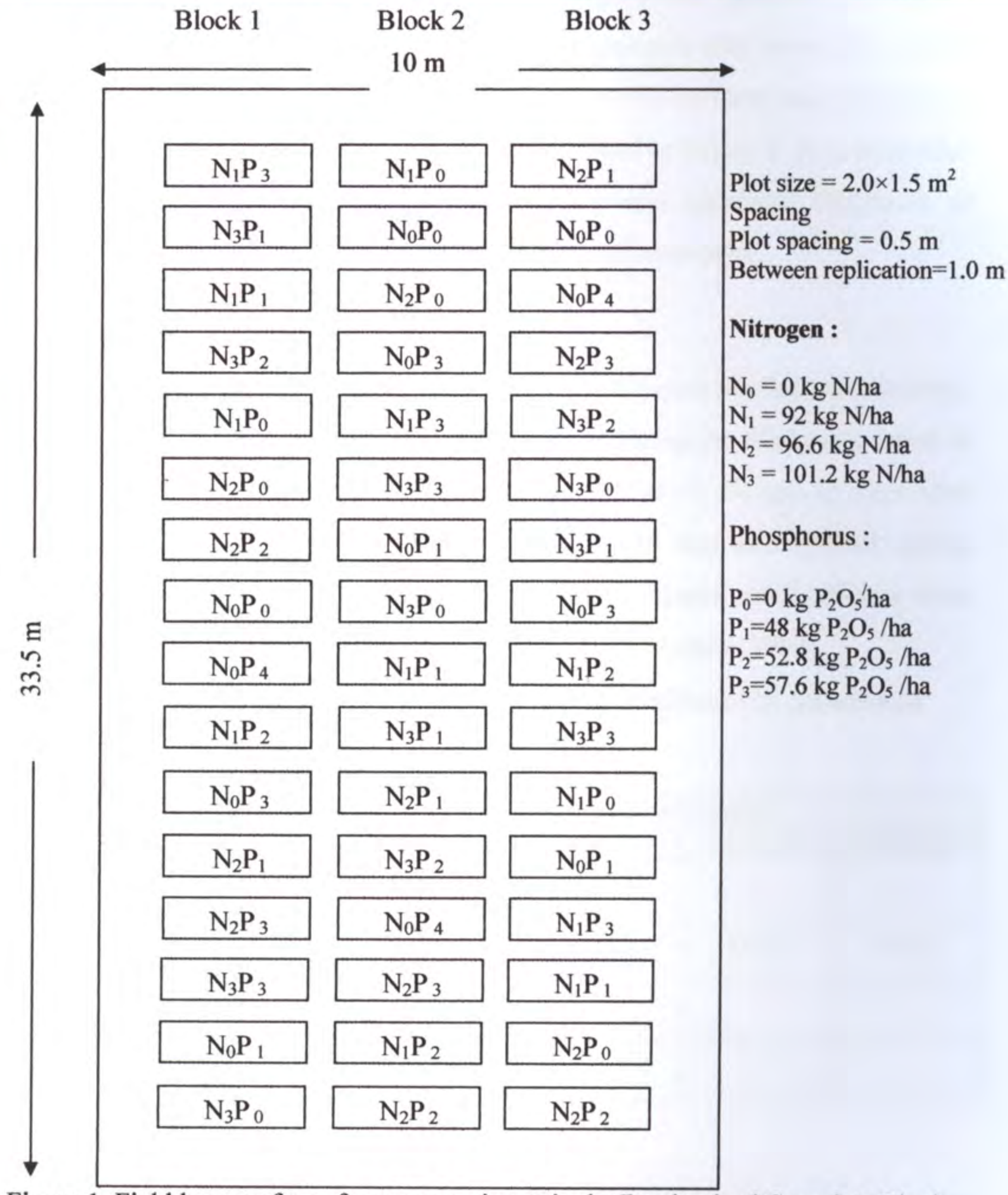

Figure 1. Field layout of two factors experiment in the Randomized Complete Block Design (RCBD)

3.7 Land preparation

The plot selected for conducting the experiment first was opened in the second week of March 2006 with a power tiller, and was 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 obtained a desirable tilth of soil for sowing of amaranth seeds. The experimental plot was partitioned into the unit plots in accordance with the experimental design mentioned in Figure 1. Recommended doses of well-decomposed cowdung manure and chemical fertilizers as indicated in below were mixed with the soil of each unit plot.

3.8 Application of Manure and Fertilizers

The sources of N, P_2O_5 , K_2O as urea, TSP and MP were applied, respectively. The entire amounts of TSP and MP were applied during the final preparation of land. Urea was applied in three equal installments at 15, 30 and 45 days after seed sowing of amaranth. Well-rotten cowdung 20 t/ha also applied during final land preparation. The following amount of manures and fertilizers were used which shown as tabular form recommended by Rashid (1993).

Table 1. Dose and method of application of fertilizers in amaranth field

Manures and fertilizers	Dose per hectare	Application (%)			
		Basal	15 DAS	30 DAS	45 DAS
Cowdung	20 tons	100	--	--	--
Nitrogen	As treatment	--	33.33	33.33	33.33
P_2O_5 (as TSP)	As treatment	100	--	--	--
K_2O (as MP)	200 kg	100	--	--	--

3.9 Intercultural operation

When the seedlings started to emerge in the beds it was always kept under careful observation. After emergence of seedlings, various intercultural operations irrigation, thinning, weeding, top dressing was accomplished for better growth and development of the amaranth seedlings.

3.9.1 Irrigation

Over-head irrigation was provided with a watering can to the plots once immediately after germination and continued for three times for proper growth and development of plants.

3.9.2 Thinning

The seedlings were first thinned from all of the plots after 10 DAS after sowing and were continued at 7 days interval for proper growth and development of amaranth seedlings.

3.9.3 Weeding

Weeding was done to keep the plots free from weeds, 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 is necessary. Breaking the crust of the soil was done when needed.

3.9.4 Top Dressing

After basal dose, the remaining doses of urea were top-dressed in 3 equal installments. The fertilizers were applied on both sides of plant rows and mixed well with the soil. Eathing up operation was done immediately after top-dressing of nitrogenous fertilizer.

3.10 Plant Protection

Tilt 250 EC fungicide (0.04%) was applied after 30 days month of seeds sowing with 1 ml in 2.5 litre water as a preventative measure against different fungal diseases.

3.11 Harvesting

The crop was harvested depending upon the optimum duration of maturity which ensured the better condition for consume. Harvesting was done at 55 DAS manually with a help of knife.

3.12 Data collection

Data on different green yield and related to yield contributing characters were recorded and collection procedure in this respect are presented under the following headings

3.12.1 Plant height (cm)

The height of plant was recorded in centimeter (cm) at harvest in the experimental plots. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot starting from 20 DAS to harvest at 10 days and 15 days interval. The height was measured from the ground level to the tip of the growing point.

3.12.2 Number of leaves per plant

The total number of leaves arise from the main stem of a plant was counted as the number of leaves per plant. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot starting from 20 DAS to harvest at 10 days and 15 days interval.

3.12.3 Stem diameter (mm)

Stem diameter of amaranth plant was measured in millimeter (mm) with a thread and then in a meter scale as the outer surface of the stem. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot starting from 20 DAS to harvest at 10 days and 15 days interval and mean value for each stem diameter was recorded.

3.12.4 Fresh weight of leaves per plant (g)

Leaves of ten randomly selected plants were detached by a sharp knife and average fresh weight of leaves was recorded in gram.

3.12.5 Dry weight of leaves per plant (g)

After harvesting, randomly selected 100gm of leaf sample previously sliced into very this pieces were put into envelop an placed in over maintained at 60^0 c for 72hours. The sample was then transferred in to desiccators and allowed to cool down to the room temperature. The final weight of the sample was taken.

3.12.6 Fresh weight of stem per plant (g)

Weight of ten selected plant without leaves were recorded during harvest from each plot and measured in gram.

3.12.7 Dry weight of stem per plant (g)

After harvesting, randomly selected 100gm of stem sample previously sliced into very thin pieces were put into envelop and placed in oven maintained at 60^0 c for 70 hours. The sample was then transferred into desiccators and allowed to cool down to the room temperature. The final weight of the sample was taken.

3.12.8 Green Yield (kg per plot)

Yield of amaranth per plot was recorded as the above ground plant weight of 10 selected plants within a plot (2.0 m × 1.5 m) and was expressed in kilogram. Yield included weight of stem with leaves and total at different harvested time.

3.12.9 Green Yield (ton per hectare)

Yield per hectare of amaranth was calculated by converting the weight of plot yield to hectare and was expressed in ton.

3.13 Statistical Analysis

The data obtained for different characters were statistically analyzed to find out the significance of the difference levels of nitrogenous and phosphorus fertilizers on yield and yield contributing characters of stem amaranth. The mean values of all the characters were evaluated and analysis of variance was performing by the 'F' (variance ratio) test. The significance of the difference among the treatment combinations means was estimated by the least significant difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

3.14 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment combination of nitrogen and phosphorous. All input cost include the cost for lease of land and interests on running capital were considered in computing the cost of production. The interests were calculated @ 13% for six months. The market price of stem amaranth was considered for estimating the cost and return. Analyses were done details according to the procedure of Alam *et al.* (1989). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

CHAPTER IV

RESULT AND DISCUSSION

RESULTS AND DISCUSSION

The present experiment was conducted to determine the effect of different levels of nitrogen and phosphorus on growth and yield of amaranth. Data on different yield contributing characters and yield at different days after sowing (DAS) was recorded for find out the optimum levels of nitrogen and phosphorous. The analysis of variance (ANOVA) of the data on different yield components and yield of amaranth are given in Appendix III-V. The results have been presented and discussed, and possible interpretations have been given under the following headings:

4. Effect of nitrogen and phosphorus on growth and yield

4.1 Plant height

A significant variation was found in respect of plant height in relation with different levels of nitrogen (Appendix III). Although all the levels of nitrogen, which were applied in the present trail, showed a gradual increase trend in height of amaranth start from 20 DAS to till the harvest (Figure 2). The tallest (88.82 cm) plant during harvesting period was recorded in N_3 which was closely followed by N_2 (84.99 cm) and N_1 (81.95 cm), respectively at 55 DAS. The shortest (76.01 cm) plant height was recorded from control with no nitrogen. The results indicated that nitrogen increase the growth of plant which ensure the maximum height of plant than control. The results of this study are comparable to the findings of Vijayakumar *et al.* (1982) who reported that plant height at 30 DAS and ranged from 16.05 to 57.25 cm, at 40 DAS it ranged from 34.95-70.25 cm and 45 DAS ranged from 65 to 122.15 cm.

Phosphorus showed a statistically significant variation was recorded in terns of plant height in relation with different doses of phosphorous (Appendix III). Although all the level of this, which was used as treatment in the present experiment, showed a regular increase in height of amaranth start from 20 DAS to till harvest (Figure 3). The tallest (85.40 cm) plant during harvest was recorded in P_3 which was closely followed with the phosphorous doses at P_2 and P_1 respectively (83.59 cm and 82.32 cm) at harvest (55 DAS).The shortest (80.46 cm) plant height was recorded in the plot with no phosphorous. The results indicated that phosphorous increases the growth and development as well as ensure the availability of other nutrients for plant and the ultimate results is the maximum height of plant than control condition. Similar trend of results also found by Talukder (1999) who recorded that the highest of plant height was recorded by using P_2O_5 @ 48 kg/ha. Hossain (1996) also support this result.

Interaction effect between nitrogen and phosphorous showed no significant differences in consideration of plant height of amaranth (Appendix III).The maximum (92.41 cm) height during harvest was recorded in N_3P_3 and the shortest (71.22 cm) plant height was recorded in control treatment (Table 2). With the maximum doses of nitrogen and phosphorous ensure the availability of nutrients materials in the soil and the ultimate results maximum photosynthesis as well as highest growth of the plant.

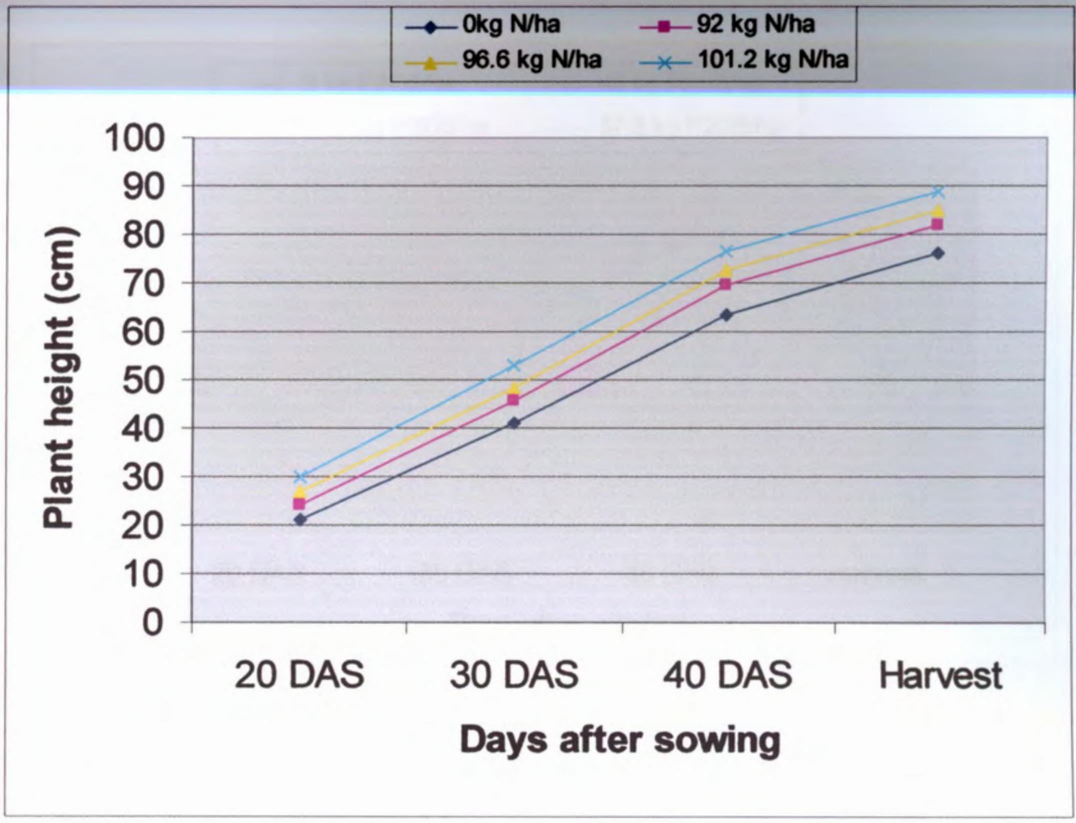

Fig. 2. Effect of different levels of nitrogen on plant height of stem amaranth

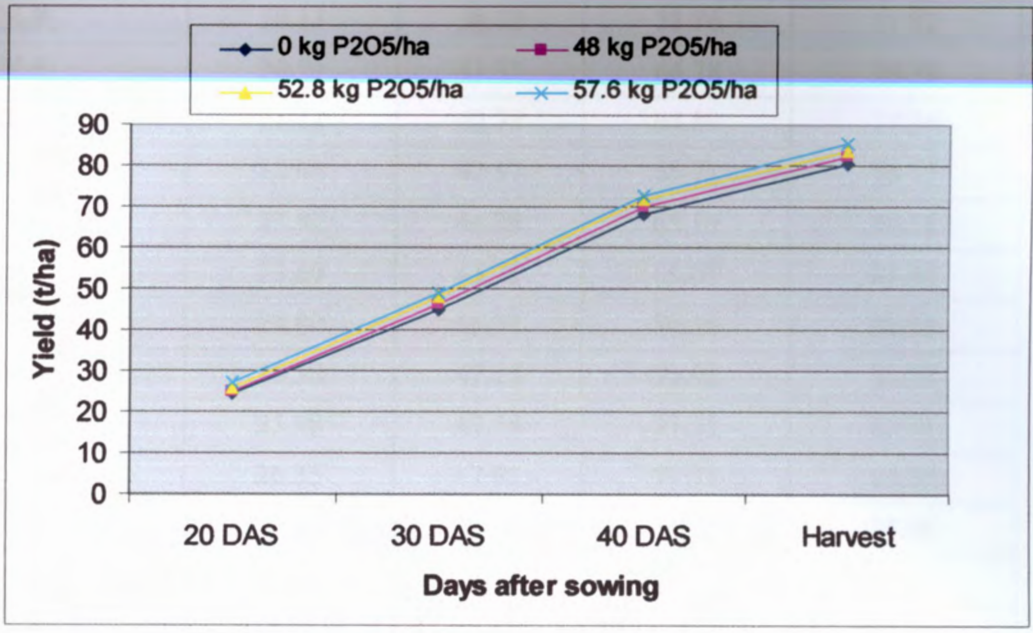

Fig. 3. Effect of different levels of phosphorus on plant height of stem amaranth

Table 2. Interaction effect of different levels of nitrogen and phosphorus on plant height of stem amaranth

Nitrogen × Phosphorus	Plant height (cm) at			
	20 DAS	30 DAS	40 DAS	harvest
N_0P_0	20.13	38.32	58.86	71.22
N_0P_1	20.71	41.31	64.78	76.78
N_0P_2	21.18	42.75	64.89	77.26
N_0P_3	22.67	42.57	65.71	78.77
N_1P_0	22.82	44.38	68.19	80.55
N_1P_1	23.69	45.25	69.07	81.40
N_1P_2	24.80	46.37	70.18	82.55
N_1P_3	25.58	47.15	70.96	83.29
N_2P_0	25.98	47.54	71.35	83.71
N_2P_1	26.35	47.91	71.73	84.06
N_2P_2	27.32	48.87	72.73	85.06
N_2P_3	28.73	50.30	74.78	87.12
N_3P_0	28.62	50.19	74.01	86.35
N_3P_1	29.32	50.88	74.69	87.04
N_3P_2	30.41	54.32	79.13	89.48
N_3P_3	31.67	56.57	79.05	92.41
$LSD_{(0.05)}$	--	--	--	--
Level of significance	NS	NS	NS	NS
CV (%)	6.02	4.90	5.23	4.49

NS= not significant

N_0 = Control
N_1 = 92 kg Nitrogen/ha
N_2 = 96.6 kg Nitrogen/ha
N_3 = 101.2 kg Nitrogen/ha

P_0 = Control
P_1= 48.0 kgP2O5 /ha
P_2 = 52.8 kgP2O5 /ha
P_3 = 57.6 kgP2O5 /ha

4.2 Number of leaves per plant

Different doses of nitrogen showed a statistically significant variation in terms of number of leaves (Appendix III). All the level of nitrogen, which was applied in the present experiment, showed an increasing trend in number of leaves at 20 DAS, 30 DAS 40 DAS and finally at harvest (Table 3). The maximum (52.89) number of leaves per plant at harvest was recorded in N_3 which was statistically similar with N_2 (51.23). The minimum (43.31) number of leaves at harvest was recorded in the plot with no nitrogen at harvest. The results indicated that nitrogen increase the growth of plant as well as maximum number of leaves. Similar trend of result was also observed by Arfin (2006), who found that the maximum number of leaves per plant were obtained from nitrogen 102 kg/ha level.

Different doses of phosphorous showed a statistically significant variation in consideration of number of leaves (Appendix III). All the level of phosphorous, which was applied in the present experiment, showed an increasing trend in number of leaves at 20 DAS, 30 DAS 40 DAS and finally at harvest (Table 4). The maximum (50.80) number of leaves per plant at harvest was recorded in P_3 which was statistically similar with the phosphorous doses at P_2 and P_1 (50.32, 49.07, respectively). The minimum (46.44) number of leaves at harvest was recorded from the plot with no phosphorous. The result of this study favored the findings of Portal (1992), who stated that number of leaves per plant increased with the increasing level of P_2O_5.

Interaction effect between nitrogen and phosphorous showed no significant variation in consideration of number of leaves of amaranth (Appendix III). The maximum (54.72) number of leaves during harvest was recorded in N_3P_3 and the minimum (41.19) number of leaves was obtained from control treatment (Table 5).

Table 3. Effect of different levels of nitrogen on number of leaves of stem amaranth

Nitrogen	Number of leaves per plant at			
	20 DAS	30 DAS	40 DAS	harvest
0 kg N/ha (N_0)	11.01 d	18.26 d	33.23 c	43.31 c
92 kg N/ha (N_1)	14.22 c	22.81 c	37.94 b	49.19 b
96.6 kg N/ha (N_2)	17.09 b	25.18 b	40.40 a	51.23ab
101.2 kg N/ha (N_3)	20.00 a	27.26 a	42.06 a	52.89 a
$LSD_{(0.05)}$	1.218	1.402	1.798	2.218
Level of significance	**	**	**	**

Means followed by different letters in a column differed significantly by LSD at 5% level.

** Significant at 0.01 level of probability

Table 4. Effect of different levels of phosphorus on number of leaves of stem amaranth

Phosphorus	Number of leaves per plant at			
	20 DAS	30 DAS	40 DAS	harvest
0 kg P_2O_5/ha (P_0)	14.22 c	21.98 c	36.53 b	46.44 b
48 kg P_2O_5/ha (P_1)	15.02bc	22.94bc	38.16ab	49.07 a
52.8 kg P_2O_5/ha (P_2)	15.93 b	23.93ab	39.23 a	50.32 a
57.6 kg P_2O_5/ha (P_3)	17.16 a	24.67 a	39.72 a	50.80 a
$LSD_{(0.05)}$	1.218	1.402	1.798	2.218
Level of significance	**	**	**	**

Means followed by different letters in a column differed significantly by LSD at 5% level.

** Significant at 0.01 level of probability

Table 5. Interaction effect of different levels of nitrogen and phosphorus on number of leaves of stem amaranth

Nitrogen × Phosphorus	Number of leaves per plant at			
	20 DAS	30 DAS	40 DAS	harvest
N_0P_0	9.47	16.72	32.27	41.19
N_0P_1	10.71	17.97	32.52	42.77
N_0P_2	11.18	18.77	33.32	44.24
N_0P_3	12.67	19.59	34.81	45.06
N_1P_0	12.82	21.41	35.29	46.54
N_1P_1	13.69	22.28	37.83	49.08
N_1P_2	14.80	23.39	38.94	50.19
N_1P_3	15.58	24.17	39.72	50.97
N_2P_0	15.98	24.57	38.12	48.03
N_2P_1	16.35	24.94	40.49	51.74
N_2P_2	17.32	25.91	41.46	52.71
N_2P_3	18.73	25.32	41.53	52.45
N_3P_0	18.62	25.21	40.42	50.01
N_3P_1	19.32	26.57	41.79	52.71
N_3P_2	20.41	27.67	43.22	54.14
N_3P_3	21.67	29.59	42.81	54.72
$LSD_{(0.05)}$	--	--	--	--
Level of significance	NS	NS	NS	NS
CV (%)	9.38	7.71	5.79	5.41

Means followed by different letters in a column differed significantly by LSD at 5% level.
NS= not significant

N_0 = Control
N_1 = 92 kg Nitrogen/ha
N_2 = 96.6 kg Nitrogen/ha
N_3 = 101.2 kg Nitrogen/ha

P_0 = Control
P_1= 48.0 kgP2O5 /ha
P_2 = 52.8 kgP2O5 /ha
P_3 = 57.6 kgP2O5 /ha

4.3 Stem diameter

A significant variation was recorded in consideration of different levels of nitrogen in terms of stem diameter (Appendix IV). At different harvesting time stem diameter exhibit an increasing tend in stem diameter at 20 DAS, 30 DAS 40 DAS and finally at harvest (Table 6). The maximum (23.76 mm) stem diameter at harvest was recorded in N_3. The minimum (13.84 mm) stem diameter at harvest was recorded in the plot with no nitrogen. The results indicated that nitrogen increases the vegetative growth of amaranth as well as maximum stem diameter.

A significant variation was recorded from different levels of phosphorous in respect of stem diameter (Appendix IV). At different harvesting time stem diameter exhibit an increasing tend in stem diameter at 20, 30, 40 DAS and finally at harvest (55 DAS). The maximum (22.22 mm) stem diameter at harvest was recorded in P_3 which was statistically similar (21.90 mm) with P_2. The minimum (20.95 mm) stem diameter at harvest was recorded in the plot with no phosphorous (Table 7). The results indicated that phosphorous increases the vegetative growth of amaranth as well as maximum stem diameter. This result is supported by the findings of Talukder (1999), who reported that plant diameter ranges from 2.35 to 2.98 cm at 44 DAS. Hossain (1996) also found similar types of results.

There was no interaction effect between nitrogen and phosphorous was recorded in terms of petiole stem diameter of amaranth (Appendix IV).The maximum (24.46 mm) stem diameter during harvest was recorded in N_3P_3 and the minimum (18.30 mm) stem diameter was found from control treatment (Table 8).

Table 6. Effect of different levels of nitrogen on stem diameter of stem amaranth

Nitrogen	Stem diameter (mm) at			
	20 DAS	30 DAS	40 DAS	harvest
0 kg N/ha (N_0)	10.53 d	13.84 d	17.58 d	19.53 d
92 kg N/ha (N_1)	11.57 c	15.10 c	19.24 c	21.10 c
96.6 kg N/ha (N_2)	12.66 b	16.22 b	20.36 b	22.26 b
101.2 kg N/ha (N_3)	14.22 a	17.84 a	21.74 a	23.76 a
$LSD_{(0.05)}$	0.634	0.693	0.854	0.845
Level of significance	**	**	**	**

Means followed by different letters in a column differed significantly by LSD at 5% level.

** Significant at 0.01 level of probability

Table7. Effect of different levels of phosphorus on stem diameter of stem amaranth

Phosphorus	Stem diameter (mm) at			
	20 DAS	30 DAS	40 DAS	harvest
0 kg P_2O_5 /ha (P_0)	11.68 c	15.07 c	19.04 b	20.95 b
48 kg P_2O_5 /ha (P_1)	11.99bc	15.53bc	19.63ab	21.57ab
52.8 kg P_2O_5 /ha (P_2)	12.52ab	15.99ab	19.91ab	21.90 a
57.6 kg P_2O_5 /ha (P_3)	12.80 a	16.40 a	20.34 a	22.22 a
$LSD_{(0.05)}$	0.634	0.693	0.854	0.845
Level of significance	**	**	**	**

Means followed by different letters in a column differed significantly by LSD at 5% level.

** Significant at 0.01 level of probability

Table 8. Interaction effect of different levels of nitrogen and phosphorus on stem diameter of stem amaranth

Nitrogen × Phosphorus	Stem diameter (mm) at			
	20 DAS	30 DAS	40 DAS	Harvest
N_0P_0	9.93	12.95	16.21	18.30
N_0P_1	10.56	14.13	18.28	20.25
N_0P_2	10.82	13.91	17.68	19.58
N_0P_3	10.81	14.36	18.16	20.00
N_1P_0	11.65	15.17	19.38	21.15
N_1P_1	10.96	14.40	18.55	20.43
N_1P_2	12.00	15.53	19.64	21.52
N_1P_3	11.67	15.30	19.41	21.30
N_2P_0	12.15	15.59	19.84	21.73
N_2P_1	12.51	16.09	20.19	22.11
N_2P_2	12.45	16.08	20.17	22.07
N_2P_3	13.52	17.14	21.24	23.13
N_3P_0	12.97	16.59	20.73	22.64
N_3P_1	13.91	17.51	21.53	23.51
N_3P_2	14.82	18.43	22.17	24.42
N_3P_3	15.19	18.81	22.55	24.46
$LSD_{(0.05)}$	--	--	--	--
Level of significance	NS	NS	NS	NS
CV (%)	6.21	5.28	5.19	4.68

Means followed by different letters in a column differed significantly by LSD at 5% level.
NS= not significant

N_0 = Control
N_1 = 92 kg Nitrogen/ha
N_2 = 96.6 kg Nitrogen/ha
N_3 = 101.2 kg Nitrogen/ha

P_0 = Control
P_1= 48.0 kgP2O5 /ha
P_2 = 52.8 kgP2O5 /ha
P_3 = 57.6 kgP2O5 /ha

4.4 Fresh weight of leaves

Significant variation in respect of fresh weight of leaves per plant were recorded all growth stages of plant (Appendix IV). The maximum (76.39 g) fresh weight of leaves per plant was obtained from N_3 while the minimum (62.09 g) fresh weight was found in N_0. The maximum fresh weight was possibly to long time photosynthesis which leads to more deposition of photosynthates during the vegetative growth of plants (Table 9). This result is supported by the findings of Arfin (2006), who reported that, the maximum fresh weight of leaves were found from highest level (102 kg N/ha) of Nitrogen. Rajagopal (1977) also found that the weight of leaves per plant were 98 g at 35 DAS by the application of N at highest level.

Significant variation in respect of fresh weight of leaves per plant were recorded all growth stages of plant (Appendix IV). The maximum (71.72) fresh weight of leaves per plant was obtained from P_3 while the minimum (68.05) fresh weight was found in P_0 (Table 10). The maximum fresh weight was possibly to long time photosynthesis which lead to more deposition of photosynthates during the vegetative growth of plants. The result on fresh weight of leaves/ plants at different DAS in this experiment are comparable with the findings of Talukder (1999), who found the fresh leaves weight per plant 92 g at 44 DAS in stem amaranth.

Interaction effect between nitrogen and phosphorus also showed significant variation on fresh weight of leaves in all growth stages of plant (Appendix IV). The maximum (77.40 g) fresh weight of leaves per plant was obtained from N_3P_3 while the minimum (58.25 g) fresh weight was observed in control (Table11). The maximum fresh weight of leaves was possibly to long time photosynthesis which lead to more deposition of photosynthates during the vegetative growth of plants.

4.5 Dry weight of leaves

A significant variation in respect of dry weight of leaves per plant was recorded all growth stages of plant (Appendix IV). The maximum (8.05 g) dry weight of leaves per plant was obtained from N_3 while the minimum (7.04 g) dry weight was recorded from N_0. Dry weight of leaves from different nitrogen levels was increased up to a certain period (Table 9). Ayodele *et al.* (2002) found similar trend of results in case of dry weight of leaves per plant (Table 4). Similar trend of results also reported by Arfin (2006) but Rajagopal *et a.l*(1977) fresh weight of stem was found 220-270 g at 40 DAS with application of N @ 102 kg/ha.

A significant variation in respect of dry weight of leaves per plant was recorded all growth stages of plant (Appendix IV). The maximum (7.94 g) dry weight of leaves per plant was obtained from P_3 while the minimum (7.25 g) dry weight was found from control treatment. Dry weight of leaves from different nitrogen levels was increased up to a certain period (Table 10).

A combined significant effect was found between nitrogen and phosphorus on dry weight of leaves A (Appendix IV). The maximum (8.25 g) dry weight of leaves per plant was obtained from N_3P_3 while the minimum (6.78 g) dry weight was found in control treatment (N_0P_0). Dry weight of leaves from different nitrogen levels was increased up to harvest.

4.6 Fresh weight of stem

Significant variation in respect of fresh weight of stem per plant were recorded all growth stages of plant (Appendix IV). The maximum (223.49 g) fresh weight of stem per plant was obtained from N_3 while the minimum (182.24 g) fresh weight was found in N_0. The maximum fresh weight of stem was possibly to long time photosynthesis which lead to more deposition of photosynthates during the vegetative growth of plants.

Significant variation in respect of fresh weight of stem per plant were recorded all growth stages of plant (Appendix IV). The maximum (208.71 g) fresh weight of stem per plant was obtained from P_3 while the minimum (197.37 g) fresh weight was found in control treatment. The maximum fresh weight of stem was possibly to long time photosynthesis which lead to more deposition of photosynthates during the vegetative growth of plants. Results on fresh weight of stem obtained in this experiment also comparable to the results of Talukder (1999).

The combined effect of nitrogen and phosphorus on fresh weight of stem per plant was also significant (Appendix V). The maximum (229.71 g) fresh weight of stem per plant was obtained from N_3P_3 while the minimum (172.78 g) fresh weight was found in control. The maximum fresh weight of stem per plant was possibly to long time photosynthesis which lead to more deposition of photosynthates during the vegetative growth of plants.

4.7 Dry weight of stem

A significant variation in respect of dry weight of stem per plant was recorded all growth stages of plant (Appendix IV). The maximum (7.45 g) dry weight of stem per plant was obtained from N_3 while the minimum (6.69 g) dry weight was observed in N_0. Dry weight of stem from different nitrogen levels was increased up to a certain period. In every levels of nitrogen performed increasing trends to vigorus growth of stem which produced higher dry matter (Table 9). Diaz-ortega *et al.*(2004) observed that with the increasing of N level biomass production of stem amaranth increased significantly that increases the dry matter of stem and leaves. Arfin (2006) also reported that N @ 102 kg/ha increases the dry weight of plant.

A significant variation in respect of dry weight of stem per plant was recorded all growth stages of plant (Appendix IV). The maximum (7.38) dry weight of stem per plant was obtained from P_3 while the minimum (6.93) dry weight was found in control treatment. Dry weight of stem from different nitrogen levels was increased up to a certain period. In every levels of nitrogen performed increasing trends to vigorous growth of stem which produced higher dry matter. Similar trend of result also obtained by Hossain (1996) who found that the dry weight of stem were ranged from 7.26 to 10.07 % at 55 DAS.

The combined effect of nitrogen and phosphorus was not found significant in respect of dry weight of stem per plant (Appendix IV). The maximum (7.61 g) dry weight of stem per plant was obtained from N_3 P_3 and the minimum (6.43g) dry weight was found from control. Dry weight of stem from different nitrogen levels was increased up to a certain period. In every levels of nitrogen performed increasing trends to vigorous growth of stem which produced higher dry matter.

Table 9. Effect of different levels of nitrogen on fresh and dry weight of leaves and stem of stem amaranth

Nitrogen	Weight of leaves per plant (g)		Weight of stem per plant (g)	
	Fresh	Dry	Fresh	Dry
0 kg N/ha (N_0)	62.09 d	7.04 b	182.24d	6.69 b
92 kg N/ha (N_1)	68.85 c	7.45 a	196.11c	7.43 a
96.6 kg N/ha (N_2)	72.98 b	7.92 a	209.72b	7.55 a
101.2 kg N/ha (N_3)	76.39 a	8.05 a	223.49a	7.45 a
$LSD_{(0.05)}$	2.583	0.314	6.283	0.239
Level of significance	**	**	**	**

Means followed by different letters in a column differed significantly by LSD at 5% level.
** Significant at 0.01 level of probability

Table 10. Effect of different levels of phosphorus on fresh and dry weight of leaves and stem of stem amaranth

Phosphorus	Leaves per plant		Stem per plant	
	Fresh weight	Dry weight	Fresh weight	Dry weight
0 kg P_2O_5 /ha (P_0)	68.05 b	7.25 b	197.37c	6.93 b
48 kg P_2O_5 /ha (P_1)	69.64ab	7.99 a	201.30bc	7.43 a
52.8 kg P_2O_5 /ha (P_2)	70.90 a	7.87 a	204.18ab	7.38 a
57.6 kg P_2O_5 /ha (P_3)	71.72 a	7.94 a	208.71 a	7.38 a
$LSD_{(0.05)}$	2.583	0.314	6.283	0.239
Level of significance	*	**	**	**

Means followed by different letters in a column differed significantly by LSD at 5% level.
** Significant at 0.01 level of probability
* Significant at 0.05 level of probability

Table 11. Interaction effect of different levels of nitrogen and phosphorus on fresh and dry weight of leaves and stem of stem amaranth

Nitrogen × Phosphorus	Weight of leaves per plant		Weight of stem per plant	
	Fresh	Dry	Fresh	Dry
N_0P_0	58.25	6.78	172.8	6.43
N_0P_1	61.30	7.26	181.3	6.89
N_0P_2	63.61	6.80	185.5	6.72
N_0P_3	65.18	7.30	189.3	6.72
N_1P_0	67.39	7.49	192.3	6.91
N_1P_1	68.85	8.23	195.3	7.61
N_1P_2	69.15	8.23	196.3	7.37
N_1P_3	70.00	8.25	200.3	7.61
N_2P_0	71.55	7.20	205.3	7.61
N_2P_1	72.15	8.25	207.9	7.60
N_2P_2	73.95	8.23	210.5	7.00
N_2P_3	74.28	7.99	215.5	7.60
N_3P_0	75.00	7.52	219.3	7.61
N_3P_1	76.27	8.23	220.5	7.60
N_3P_2	76.90	8.23	224.4	7.61
N_3P_3	77.40	8.25	229.7	7.61
$LSD_{(0.05)}$	--	--	--	--
Level of significance	*	*	*	NS
CV (%)	4.42	3.71	4.86	3.94

Means followed by different letters in a column differed significantly by LSD at 5% level.
* Significant at 0.05 level of probability
NS= not significant

N_0 = Control
N_1 = 92 kg Nitrogen/ha
N_2 = 96.6 kg Nitrogen/ha
N_3 = 101.2 kg Nitrogen/ha

P_0 = Control
P_1= 48.0 kgP2O5 /ha
P_2 = 52.8 kgP2O5 /ha
P_3 = 57.6 kgP2O5 /ha

4.8 Green yield (kg /plot)

A statistically significant variation was recorded for green yield of amaranth per plot in reflection with different levels of nitrogen (Appendix IV). All harvesting time of data recorded level of nitrogen performed an increasing trend in green yield (Table 12). The highest (22.94 kg) plot yield at finally harvest was recorded in N_3 which was closely followed by N_2 (21.39 kg). The lowest (11.96 kg) yield per plot was recorded in the plot with no nitrogen. The results indicated that nitrogen ensure the proper growth of amaranth as well as highest yield compare the control. Arfin (2006) observed that green yield per plot were significantly increased by N level up to 102 kg/ha. Sekhar (1998) also stated similar trend of results.

A statistically significant variation was recorded for green yield of amaranth per plot in reflection with different levels of phosphorous (Appendix IV). All harvesting time of data recorded level of phosphorous performed an increasing trend in green yield (Table 13). The highest (20.40 kg) plot yield at finally harvest was recorded in P_3 which was closely followed with the phosphorous levels at P_2 (20.29 kg). The lowest (15.18 kg) yield per plot was observed in the plot with no phosphorous. The results indicated that phosphorous ensure the proper growth of amaranth as well as highest yield compare the control.

Nitrogen and phosphorous showed significant variation in terms of yield per plot of amaranth (Appendix IV). The highest (25.00 kg) yield per plot during harvest was recorded in N_3P_3 and the lowest (10.46 kg) yield was recorded from control condition (Table 14).

Table 12. Effect of different levels of nitrogen on green yield (kg/plot) of stem amaranth

Nitrogen	Green yield (kg per plot) at			
	20 DAS	30 DAS	40 DAS	harvest
0 kg N/ha (N_0)	3.66 c	6.31 c	8.28 c	11.96 d
92 kg N/ha (N_1)	4.17 b	7.12 b	11.22 b	18.50 c
96.6 kg N/ha (N_2)	4.21 b	7.20 b	11.76 b	21.39 b
101.2 kg N/ha (N_3)	5.03 a	9.01 a	13.87 a	22.94 a
$LSD_{(0.05)}$	0.343	0.696	0.995	1.370
Level of significance	**	**	**	**

Means followed by different letters in a column differed significantly by LSD at 5% level.
** Significant at 0.01 level of probability

Table 13. Effect of different levels of phosphorus on green yield (kg/Plot) of stem amaranth

Phosphorus	Green yield (kg per plot) at			
	20 DAS	30 DAS	40 DAS	harvest
0 kg P_2O_5/ha (P_0)	4.00 b	6.80 b	10.37 c	15.18 c
48 kg P_2O_5/ha (P_1)	4.22 ab	7.24 b	11.04bc	18.93 b
52.8 kg P_2O_5/ha(P_2)	4.27 ab	7.41 b	11.45ab	20.29ab
57.6 kg P_2O_5/ha(P_3)	4.58 a	8.20 a	12.27 a	20.40 a
$LSD_{(0.05)}$	0.343	0.696	0.995	1.370
Level of significance	**	**	**	**

Means followed by different letters in a column differed significantly by LSD at 5% level.

** Significant at 0.01 level of probability

Table 14. Interaction effect of different levels of nitrogen and phosphorus on green yield (kg/plot) of stem amaranth

Nitrogen × Phosphorus	Green yield (kg per plot) at			
	20 DAS	30 DAS	40 DAS	harvest
N_0P_0	3.42	5.66	6.25	10.46
N_0P_1	3.49	5.64	7.52	12.17
N_0P_2	3.71	6.40	8.92	12.49
N_0P_3	4.03	7.55	10.44	12.74
N_1P_0	4.01	6.78	10.24	13.30
N_1P_1	3.88	6.49	10.93	18.58
N_1P_2	4.33	7.48	11.63	20.47
N_1P_3	4.44	7.71	12.10	21.64
N_2P_0	3.84	6.40	12.53	17.91
N_2P_1	4.21	7.22	11.09	22.52
N_2P_2	4.18	7.14	11.27	22.93
N_2P_3	4.59	8.05	12.14	22.22
N_3P_0	4.74	8.37	12.47	19.05
N_3P_1	5.30	9.60	14.65	22.46
N_3P_2	5.24	9.47	14.39	25.00
N_3P_3	4.85	8.62	13.97	25.26
$LSD_{(0.05)}$	--	--	--	--
Level of significance	*	*	*	*
CV (%)	9.58	11.27	10.58	8.79

Means followed by different letters in a column differed significantly by LSD at 5% level.

* Significant at 0.05 level of probability

N_0 = Control
N_1 = 92 kg Nitrogen/ha
N_2 = 96.6 kg Nitrogen/ha
N_3 = 101.2 kg Nitrogen/ha

P_0 = Control
P_1= 48.0 kgP2O5 /ha
P_2 = 52.8 kgP2O5 /ha
P_3 = 57.6 kgP2O5 /ha

4.9 Green yield (t/ ha)

Plot yield was converted into hectare yield and recorded a statistically significant variation for green yield of amaranth per hectare in consideration with different levels of nitrogen (Appendix V). In every levels of nitrogen performed an increasing trend in green yield (Figure 4). The highest (76.47 t) yield per hectare at finally harvest was recorded in N_3 which was closely followed by N_2 (71.32 ton). The lowest (39.88) yield per hectare was recorded in the plot with no nitrogen. The results indicated that increase nitrogen ensure maximum yield compare with the control. Similar trend of result also reported by Arfin (2006) who obtained the maximum yield per ha from highest level (102 kg/ha) N level.

Recorded plot yield in every harvest of green amaranth was converted into hectare yield and recorded a statistically significant variation for green yield of amaranth per hectare in consideration with different levels of phosphorous (Appendix V). In every levels of phosphorous performed an increasing trend in green yield (Figure 5). The highest (67.99 t) yield per hectare at finally harvest was recorded in P_3 which was closely followed with the phosphorous levels at P_2 (67.63 ton). The lowest (50.60 ton) yield per hectare was obtained from the plot with no phosphorous. Santos *et al.* (2004) support with this results of present study, who reported that green yield was increased in 20% with the application of P_2O_5 @ 125 kg per ha.

Nitrogen and phosphorous showed significant variation in terms of yield per hectare of amaranth (Appendix V). The highest (83.32 ton) yield per ha during harvest was recorded from N_3P_3 and the lowest (34.86 ton) yield was observed in control treatment (Table 15).

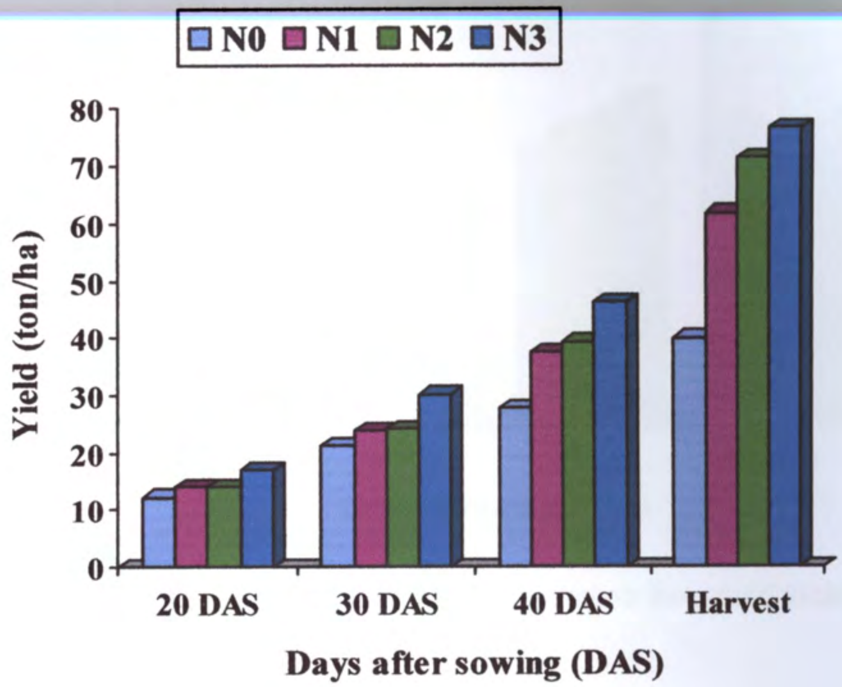

Fig 4. Effect of different levels of nitrogen on the green yield of stem Amaranth

N_0 = Control
N_1 = 92 kg Nitrogen/ha
N_2 = 96.6 kg Nitrogen/ha
N_3 = 101.2 kg Nitrogen/ha

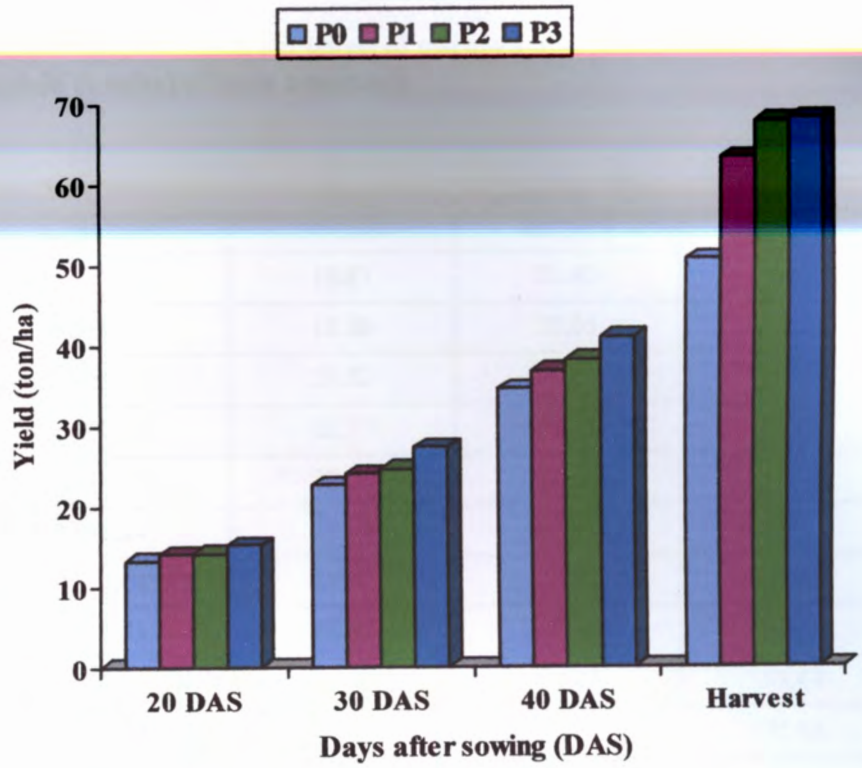

Fig 5. Effect of different levels of phosphorus on the green yield of stem amaranth

P_0 = Control
P_1 = 48.0 kgP2O5 /ha
P_2 = 52.8 kgP2O5 /ha
P_3 = 57.6 kgP2O5 /ha

Table 15. Interaction effect of different levels of nitrogen and phosphorus on green yield (ton/ha) of stem amaranth

Nitrogen × Phosphorus	Green yield (t per ha) at			
	20 DAS	30 DAS	40 DAS	harvest
N_0P_0	11.41	18.87	20.83	34.86
N_0P_1	11.64	18.80	25.05	40.56
N_0P_2	12.37	21.32	29.74	41.64
N_0P_3	13.43	25.17	34.81	42.46
N_1P_0	13.38	22.62	34.13	44.34
N_1P_1	12.94	21.64	36.43	61.94
N_1P_2	14.44	24.93	38.76	68.25
N_1P_3	14.79	25.69	40.33	72.12
N_2P_0	12.79	21.33	41.77	59.69
N_2P_1	14.04	24.05	36.96	75.08
N_2P_2	13.93	23.81	37.57	76.43
N_2P_3	15.32	26.85	40.48	74.07
N_3P_0	15.81	27.92	41.57	63.50
N_3P_1	17.67	31.99	48.82	74.87
N_3P_2	17.47	31.56	47.95	83.32
N_3P_3	16.18	28.73	46.57	84.20
$LSD_{(0.05)}$	--	--	--	--
Level of significance	*	*	*	*
CV (%)	9.63	11.27	10.58	8.79

Means followed by different letters in a column differed significantly by LSD at 5% level.
* Significant at 0.05 level of probability

N_0 = Control
N_1 = 92 kg Nitrogen/ha
N_2 = 96.6 kg Nitrogen/ha
N_3 = 101.2 kg Nitrogen/ha

P_0 = Control
P_1= 48.0 kgP2O5 /ha
P_2 = 52.8 kgP2O5 /ha
P_3 = 57.6 kgP2O5 /ha

4.10 Economic analysis

The economic analysis was done to find out the gross and net return and the benefit cost ratio in the present experiment and presented under the following headings-

4.10.1 Gross return

In the combination of different doses of Nitrogen and phosphorous highest gross return (Tk. 210500) was obtained from the treatment combination of N_3P_3 and the lowest gross return (Tk. 87150) was obtained from control treatment.

Table 16. Cost and return of stem amaranth cultivation as influenced by nitrogen and phosphorus

Nitrogen × Phosphorus	Cost of production (Tk/ha)	Yield (ton/ha)				Gross return (Tk/ha)	Net return (Tk/ha)	Benefit cost ratio
		20DAS	30DAS	40 DAS	Harvest			
N_0P_0	66681.0	11.41	18.87	20.83	34.86	87150	20469.0	0.31
N_0P_1	69513.0	11.64	18.80	25.05	40.56	101400	31887.0	0.46
N_0P_2	69701.8	12.37	21.32	29.74	41.64	104100	34398.2	0.49
N_0P_3	69890.6	13.43	25.17	34.81	42.46	106150	36259.4	0.51
N_1P_0	69513.0	13.38	22.62	34.13	44.34	110850	41337.0	0.51
N_1P_1	71589.8	12.94	21.64	36.43	61.94	154850	83260.2	1.16
N_1P_2	71778.6	14.44	24.93	38.76	68.25	170625	98846.4	1.38
N_1P_3	71967.4	14.79	25.69	40.33	72.12	180300	108332.6	1.51
N_2P_0	69607.4	12.79	21.33	41.77	59.69	149225	79617.6	1.14
N_2P_1	71684.2	14.04	24.05	36.96	75.08	187700	116015.8	1..62
N_2P_2	71873.0	13.93	23.81	37.57	76.43	191075	119202.0	1.66
N_2P_3	72061.8	15.32	26.85	40.48	74.07	185175	113113.2	1.57
N_3P_0	69701.8	15.81	27.92	41.57	63.50	158750	89048.2	1.28
N_3P_1	71778.6	17.67	31.99	48.82	74.87	187175	115396.4	1.61
N_3P_2	72159.2	17.47	31.56	47.95	83.32	208300	136140.8	1.89
N_3P_3	71697.4	16.18	28.73	46.57	84.20	210500	138532.6	1.92

4.10.2 Net return

In case of net return different treatment combination showed different types of net return. In the combination of nitrogen and phosphorous. The highest net return (Tk 138532.6.) was obtained from the treatment combination of N_3P_3 and the lowest net return (Tk 20469.0) was obtained in the control.

4.10.3 Benefit cost ratio

The highest benefit cost ratio (1.92) was attained from the treatment combination of N_3P_3 and lowest befit cost ratio (0.31) was obtained in N_0P_0.

CHAPTER V

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

A field experiment was conducted in the experimental field of Sher-e Bangla Agricultural University, Dhaka, Bangladesh during the period from March 2006 to July 2006 to study the effect of different levels of nitrogen and phosphorous fertilizer on growth and yield of amaranth. The experiment considered of two factors. Factor A: Levels of nitrogen (4 levels) i.e. No N fertilizer/Control, 92 kg/ha, 96.6 kg/ha, 101.2 kg/ha; Factor B: Levels of Phosphorus (4 levels) i.e. No P_2O_5/Control, 48 kg/ha, 52.8 kg/ha, 57.6 kg/ha. There were on the whole 16 (4 × 4) treatments combinations. The experiment was laid out in the two factors Randomized Complete Block Design (RCBD) with three replications. After emergence of seedlings, various intercultural operations were accomplished for better growth and development of the stem amaranth. Data were collected in respect of the plant growth characters and green yield of stem amaranth. The data obtained for different characters were statistically analyzed to find out the significance of the difference levels of nitrogen and phosphorous fertilizers on yield and yield contributing characters of stem amaranth.

A statistically significant variation was recorded in respect of all the recorded characters in relation with different levels of nitrogen fertilizer. The tallest plant (88.82 cm) during harvesting period was recorded in N_3 and the shortest (76.01 cm) was recorded in the plot with no nitrogen fertilizer. The maximum number of leaves/plant at harvest (52.89) was recorded in N_3 and the minimum (43.31) was recorded in the plot with no nitrogen fertilizer. The maximum stem diameter at harvest (23.76 mm) was recorded in N_3 and the minimum stem diameter at harvest (13.84 mm) was recorded in the plot with no nitrogen fertilizer. The highest plot yield at finally harvest (22.94 kg) was recorded in N_3 which was closely followed with the nitrogen levels at N_2 (21.39 kg). The lowest yield per plot (11.96 kg) was recorded in the plot with no nitrogen fertilizer. The highest yield per hectare at final harvest (76.47 t) was recorded in N_3 and the lowest yield per hectare (39.88) was recorded in the plot with no nitrogen fertilizer.

Phosphorus fertilizer showed a statistically significant variation in terms of all recorded characters in relation with different doses of phosphorous fertilizer. The tallest plant (85.40 cm) during harvest was recorded in P_3 and the he shortest plant height (80.46 cm) was recorded in the plot with no phosphorous. The maximum number of leaves/plant at harvest (50.80) was recorded in P_3 and minimum (46.44) was recorded no phosphorous fertilizer field. The maximum stem diameter at harvest (22.22 mm) was recorded in P_3. The minimum stem diameter at harvest (20.95 mm) was recorded in the plot with no phosphorous fertilizer. The highest plot yield at final harvest (20.40 kg) was recorded in P_3 and the lowest yield per plot (15.18 kg) was recorded in the plot with no phosphorous fertilizer. The highest yield per hectare at final harvest (67.99 t) was recorded in P_3 and the lowest (50.60 ton) was recorded in the plot with no phosphorous fertilizer.

There were no interaction effect between nitrogen and phosphorous fertilizer. But the maximum growth and development and yield was attained with the combination of N_3P_3 treatment and the minimum was attained in control condition. In the combination of different doses of Nitrogen and phosphorous highest benefit cost ratio (1.92) was attained from the treatment combination of N_3P_3 and lowest befit cost ratio (0.31) was obtained in N_0P_0.

Conclusion:

Therefore it may be suggested that nitrogen level at 101.2 kg/ha and phosphorus level at 57.6 kg/ha can be used to obtain higher growth and higher green yield and successful commercial amaranth production. However, further study in this relation should be carried out in other region of the country before final recommendation.

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APPENDICES

Appendix I. Results of mechanical and chemical analysis of soil of the experimental plot

Mechanical analysis

Constituents	Percent
Sand	33.45
Silt	60.25
Clay	6.20
Textural class	Silty loam

Chemical analysis

Soil properties	Amount
Soil pH	6.12
Organic carbon (%)	1.32
Total nitrogen (%)	0.08
Available P (ppm)	20
Exchangeable K (%)	0.2

Source: SRDI, Farmgate, Dhaka

Appendix II. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from March to July 2006

Month	Air temperature (^0C)		RH (%)	Total rainfall (mm)
	Maximum	Minimum		
March 06	31.25	21.55	74.65	35
April 06	33.74	23.87	85.52	69
May 06	34.20	24.20	77.35	161
June 06	33.40	26.80	69.54	179
July 06	33.52	25.35	70.44	205

Source : Dhaka metrological center

Appendix III. Analysis of variance of the data on plant height, number of leaves of stem amaranth as influenced by different levels of nitrogen and phosphorus

Source of variation	Degrees of freedom	Plant height (cm) at			
		20 DAS	30 DAS	40 DAS	harvest
Replication	2	5.102	8.834	1..834	12.306
Nitrogen (A)	3	172.41**	292.64**	368.85**	351.39**
Phosphorus (B)	3	17.409**	38.742**	47.581**	52.039**
Interaction (A×B)	9	0.132^{NS}	3.251^{NS}	5.547^{NS}	4.917^{NS}
Error	30	2.377	5.332	13.652	13.877

** Significant at 0.01 level of probability

Appendix III. Contd

Source of variation	Degrees of freedom	Mean square			
		Number of leaves/plant at			
		20 DAS	30 DAS	40 DAS	harvest
Replication	2	6.335	4.598	6.23	25.889
Nitrogen (A)	3	178.42**	179.18**	177.27**	209.62**
Phosphorus (B)	3	19.140**	16.505**	23.993**	45.669**
Interaction (A×B)	9	0.129^{NS}	1.222^{NS}	1.127^{NS}	0.540^{NS}
Error	30	2.135	3.247	4.651	7.077

** Significant at 0.01 level of probability
NS= not significant

Appendix IV. Analysis of variance of the data on stem diameter, fresh and dry weight of leaves and stem, green yield (Kg/plot and t/ha) of amaranth as influenced by different levels of nitrogen and phosphorus

Source of variation	Degrees of freedom	Mean square			
		Stem diameter (cm) at			
		20 DAS	30 DAS	40 DAS	harvest
Replication	2	0.440	0.749	1.450	1.496
Nitrogen (A)	3	29.881**	34.637**	37.209**	38.385**
Phosphorus (B)	3	3.108**	3.930**	3.549**	3.522**
Interaction (A×B)	9	0.674^{NS}	0.722^{NS}	0.949^{NS}	0.920^{NS}
Error	30	0.579	0.691	1.049	1.026

** Significant at 0.01 level of probability
NS = Not significant

Appendix IV. Contd.

Source of variation	Degrees of freedom	Mean square			
		Leaves		Stem	
		Fresh weight	Dry weight	Fresh weight	Dry weight
Replication	2	3.644	0062	16.294	0103
Nitrogen (A)	3	454.78**	2.874**	3773.01**	1.886**
Phosphorus (B)	3	30.686**	1.422**	273.952**	0.672**
Interaction (A×B)	9	28.93*	0.902*	115.11*	0.138*
Error	30	9.60	0.142	56.796	0.082

*Significant at 0.05 level of probability
** Significant at 0.01 level of probability

Appendix IV. Contd.

Source of variation	Degrees of freedom	Mean square			
		Green yield (kg/plot) at			
		20 DAS	30 DAS	40 DAS	harvest
Replication	2	0.081	0.658	0.763	6.383
Nitrogen (A)	3	3.865**	15.645**	63.657**	282.71**
Phosphorus (B)	3	0.665**	4.054**	7.536**	71.425**
Interaction (A×B)	9	0.394*	2.610*	3.840*	8.653*
Error	30	0.169	0.697	1.425	2.699

*Significant at 0.05 level of probability
** Significant at 0.01 level of probability

Appendix IV. Contd.

Source of variation	Degrees of freedom	Mean square			
		Green yield (t/ha) at			
		20 DAS	30 DAS	40 DAS	harvest
Replication	2	0.902	7.315	8.481	70.922
Nitrogen (A)	3	42.949**	173.83**	707.30**	3141.2**
Phosphorus (B)	3	7.393**	45.040**	83.73**	793.61**
Interaction (A×B)	9	10.44*	16.77*	51.55*	310.69*
Error	30	1.875	7.746	15.836	29.986

*Significant at 0.05 level of probability
** Significant at 0.01 level of probability

Appendix V
A. Material cost (Tk/ha)

Treatment	Seed (5 kg/ha) Tk.	Fertilizer and Manure				Subtotal 1 (A)
		Cow dung	Urea (8 Tk/kg)	TSP (16 Tk/kg)	MP (16 Tk/kg)	
N_0P_0	500	6000	0	0	3200	9700
N_0P_1	500	6000	0	1600	3200	11300
N_0P_2	500	6000	0	1760	3200	11460
N_0P_3	500	6000	0	1920	3200	11620
N_1P_0	500	6000	1600	0	3200	11300
N_1P_1	500	6000	1600	1600	3200	12900
N_1P_2	500	6000	1600	1760	3200	13060
N_1P_3	500	6000	1600	1920	3200	13220
N_2P_0	500	6000	1680	0	3200	11380
N_2P_1	500	6000	1680	1600	3200	12980
N_2P_2	500	6000	1680	1760	3200	13140
N_2P_3	500	6000	1680	1920	3200	13300
N_3P_0	500	6000	1760	0	3200	11460
N_3P_1	500	6000	1760	1600	3200	13060
N_3P_2	500	6000	1760	1760	3200	13220
N_3P_3	500	6000	1760	1920	3200	13380

Appendix V

B. Non-material cost (Tk/ha)

Treatment	Land preparation	Fertilizer application	Seed Sowing	Intercultural operation	Harvesting	Subtotal 1 (B)	Total Input Cost 1 (A) + 1(B)
N_0P_0	10500	0	5250	10000	7500	33250	42950
N_0P_1	10500	800	5250	10000	7500	34050	45350
N_0P_2	10500	800	5250	10000	7500	34050	45510
N_0P_3	10500	800	5250	10000	7500	34050	45670
N_1P_0	10500	800	5250	10000	7500	34050	45350
N_1P_1	10500	960	5250	10000	7500	34210	47110
N_1P_2	10500	960	5250	10000	7500	34210	47270
N_1P_3	10500	960	5250	10000	7500	34210	47430
N_2P_0	10500	800	5250	10000	7500	34050	45430
N_2P_1	10500	960	5250	10000	7500	34210	47190
N_2P_2	10500	960	5250	10000	7500	34210	47350
N_2P_3	10500	960	5250	10000	7500	34210	47510
N_3P_0	10500	800	5250	10000	7500	34050	45510
N_3P_1	10500	960	5250	10000	7500	34210	47270
N_3P_2	10500	960	5250	10000	7500	34210	47430
N_3P_3	10500	960	5250	10000	7500	34210	47590

Labor cost @ 80 Tk/day/labor

Appendix V

C. Over head cost (Tk/ha)

Treatment	Cost of lease for 6 months	Miscellaneous Cost (Tk 5% of the input cost)	Interest on running capital for 6 months (Tk 13% of cost per year)	Sub total (Tk) (B)	Total cost of production (Tk/ha)[Input cost(A)+ Over head cost (B)]
N_0P_0	16000	2147.5	5583.5	23731	66681
N_0P_1	16000	2267.5	5895.5	24163	69513
N_0P_2	16000	2275.5	5916.3	24191.8	69701.8
N_0P_3	16000	2283.5	5937.1	24220.6	69890.6
N_1P_0	16000	2267.5	5895.5	24163	69513
N_1P_1	16000	2355.5	6124.3	24479.8	71589.8
N_1P_2	16000	2363.5	6145.1	24508.6	71778.6
N_1P_3	16000	2371.5	6165.9	24537.5	71697.4
N_2P_0	16000	2271.5	5905.9	241774	69607.4
N_2P_1	16000	2359.5	6134.7	24494.2	71684.2
N_2P_2	16000	2367.5	6155.5	24523	71873
N_2P_3	16000	2375.5	6176.3	24551.8	72061.8
N_3P_0	16000	2275.5	5916.3	24191.8	69701.8
N_3P_1	16000	2363.5	6145.1	24508.6	71778.6
N_3P_2	16000	2371.5	6165.9	24537.4	71967.4
N_3P_3	16000	2379.5	6186.7	24566.2	72156.2