EFFECT OF NITROGEN ON YIELD AND YIELD CONTRIBUTING CHARACTERS OF THREE STEM AMARANTH CULTIVARS

(*Amaranthus viridus* L.)

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By

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This is to certify that the thesis entitled, "EFFECT OF NITROGEN ON YIELD AND YIELD CONTRIBUTING CHARACTERS OF THREE STEM AMARANTH CULTIVARS (*Amaranthus viridus* L.)" 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 **MOST. SADIA ARFIN, REGISTRATION NO. 25205/00331** 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 has been duly acknowledged.

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ABSTRACT

EFFECT OF NITROGEN ON YIELD AND YIELD CONTRIBUTING CHARACTERS OF THREE STEM AMARANTH CULTIVARS

(*Amaranthus viridus* L.)

By

MOST. SADIA ARFIN

Detail information on cultivars and fertilizer application in the amaranth (*Amaranthus viridus*) are limited. The response of three cultivars of amaranth viz. BARI Danta 1, Bashpata and Katua to different nitrogen (N) levels (0, 87, 92, 97 and 102 kg/ha) were examined by using Randomized Complete Block Design (RCBD) with three replications at the Horticultural Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka–1207, during the period from March to June, 2005. Besides visual acceptability of the cultivars and their taste as recorded by organoleptic test (taste and visual acceptability) based on appearance, color, flavor, taste, fibrousness, crispiness, sweetness and sourness was recorded. Application of nitrogen significantly influenced the yield and yield contributing characters of amaranth. The cultivars BARI Danta 1 and Katua showed the maximum marketable yield with the increasing application of nitrogen level. The variety Bashpata showed the maximum marketable yields with the increasing application of nitrogen level up to 97 kg/ha and then yield decreased with further increase of nitrogen application. The variety Bashpata showed the maximum yield (72.1 t/ha) with the application of 97 kg N/ha followed by Katua (65.6 t/ha) and BARI Danta 1 (34.0 t/ha) with the application of 102 kg N/ha at 55 Days After Sowing (DAS). The variety Bashpata scored the highest in total acceptability score (2828) and Katua scored the lowest (1652). The variety Bashpata and N level 97 kg/ha is the suitable combination for successful production of amaranth.

DEDICATED

TO

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CHAPTER 1

INTRODUCTION

Amaranth belongs to the genus *Amaranthus* in the family Amaranthaceae. The family Amaranthaceae comprises 65 genera and 850 species. The genus *Amaranthus* includes 50 to 60 species, the leaves and stems of which are edible. These are the most important vegetables of the tropical countries of South Asia, South East Asia, East Africa, Central Africa, West Africa, Ethiopia, the Pacific and Far East (Muthukrishnan *et al.*, 1986).

The amaranth is a native of India (Nath, 1976). The centers of diversity for amaranths are central and South America, India, South East Asia and the secondary diversity is in West Africa and East Africa (Grubben, 1977).

In 2004 total vegetable production was about 57390 thousand tons, of which 80.82% was produced in Rabi season and 19.18 % in Kharif season (Monthly Bulletin, BBS, February, 2005). It indicates scarcity of vegetables in Kharif season. Therefore, during May to September there is serious scarcity of vegetables. As a result, the price of vegetables remains high during the period.

Amaranth grown mainly during summer and rainy season is a popular vegetable in Bangladesh for their quick growth and higher yield potential. According to latest information, it is cultivated in 5263 ha land with a production of 240 thousand tons in Bangladesh having yielded 46.9 t/ha (Monthly Bulletin, BBS, February, 2005). The low yield is mainly attributed due to the use of low yielding cultivars and lack of proper cultural practices like optimum spacing, fertilizer application, irrigation, proper drainage etc. The crop produces only low yield in Bangladesh because farmers do not use optimum dose of fertilizers, due to lack of fertilizer recommendation (Hossain, 1996).

The fresh tender leaves and stem of amaranth are delicious when cooked. The fibre of amaranth works against constipation. Its lysine content is nearly three times higher than corn and nearly twice than that of wheat (Muthkrishnan and Irulappan, 1986; Shanmugavelu, 1989).

The leaves and tender stem of amaranth are rich in protein, fat, calcium, phosphorus, β-carotene, riboflavin, niacin, sodium, iron and ascorbic acid. Again, it contains food energy of about 43 calorie per 100 g edible portion, which is higher than common vegetables except potato and taroleaf (Chowdhury, 1967). Amaranth leaves are a good source of carotene, iron, calcium, vitamin C, folic acid and other micronutrient. Amaranth protein is a valuable contribution to the diet when protein intake is marginal (Shanmugavelu, 1989). The seed protein is rich in sulphur containing amino acid and lysine. Amaranth is considered as a potential up coming subsidiary food crop for future (Teutonico and Knorr, 1985). It is also considered the cheapest vegetable in the market and it could be rigidly described as a 'poor man's vegetable.

Inspite of importance of amaranth as a vegetable in Bangladesh there is little information on its fertilizer requirement.

In the above context the study has been undertaken with the following objectives:

1. To select the suitable amaranth cultivar.
2. To determine a suitable dose of nitrogen for maximum yield.

CHAPTER 2

2.1 Amaranth cultivars and fertilizers

A 2 year field experiment with N rates of 0, 80 and 120 kg N /ha for amaranth arid quinoa and 0, 30 and 60 kg N /ha for buckwheat and two cultivars of each species was conducted. Grain yield of amaranth responded to N arid ranged between 1986 and 2767 kg/ha. Nitrogen utilization efficiency (NUE) ranged from 13.9 to 15.4 kg grain yield per kg above around plant N and decreased with increasing N rate. Higher grain yields and Nitrogen utilization efficiency seemed to be mainly inhibited by the low harvest index (0.22.23) of the investigated amaranth cultivars. Quinoa yielded between 1790 and 3495 kg grain/ha and responded strongly to N fertilization. Nitrogen utilization efficiency averaged 22.2 kg/kg and did not decrease with increasing N rates. The grain yield of buckwheat did not respond to N fertilization arid averaged 1425 kg/ha. N uptake increased only slightly with N fertilization. Nitrogen utilization efficiency ranged from 16.1 to 20.0 kg/kg. Main problems occurring with the application of N to buckwheat were grain scattering and lodging (Kaul *et al.*2005).

Rathore, *et al.* (2004) grain amaranth cultivars GA-1, Suvarna arid Annapurna were supplied with 0, 30, 60 and 90 kg N/ha in a field experiment conducted in Rajasthan, India during the winter seasons of 1997-98 arid 1998-99 to identify cultivars suitable for cultivation in the region. GA-1 gave significantly higher seed yield, better growth and higher values for yield components over Suvarna and Annapurna. Seed yield increased with increasing rates of N up to 60 kg/ha. Application of N enhanced the growth and yield attributes significantly, whereas harvest index remained unaffected. The optimum and maximum rates of N, estimated through quadratic response, were 83 and 87 kg N/ha, respectively. GA-1 gave the highest gross income (Rs. 24 675/ha).

Diaz-Ortega *et al.* (2004) studied the amaranth (*Amaranthus hypochondriacus*), which is considered all alternative source of vegetable protein, is grown particularly under rainfed conditions. Therefore, it is important to look for better management practices that lead to a more efficient use of resources, such as water and essential nutrients, to obtain higher yields. The aim of this work was to determine the influence of nitrogen and plant density on the phenology, nitrogen and water use efficiency, biomass production, and seed yield of amaranth planted on 11 June 1999, with 0, 10, and 20 g N m^{2} and 12.5, 25.0, and 33.3 plants m^{2}. With the application of N and with a higher plant density (PD), N and water use efficiency and was greater, and in consequence, biomass production and yield increased as well. These increments were higher with higher N level and higher DP. With 20 g N m^{2} and 33.3 plant m^{2} a biomass production of 2827 g m^{2} and seed yield of 346 g m^{2} were obtained. Phenology was not affected by the treatments. The requirement. of sowilig heat units to physiological maturity was 1629 UC and 385 nun of water used in evapotranspiration .

Franklin (2003) reported that theories and mathematical. models were derived to arialyse arid predict plant and forest response to soil nitrogen (N) availability and atmospheric $C0_2$ concentration. Soil carbon accumulation in response to long-term fertilisation was studied using measured soil C and 14C of the organic layer in a pine forest in Northern Sweden. Fertilisation increased forest growth arid drastically reduced long-term litter decomposition through effects on the decomposers. In 100 years, twice as much carbon would be accumulated in the forest soil where N addition is high as where no N addition occurs. Root:shoot allocation of small plants was modelled using maximisation of relative growth rate, with and without explicit inclusion of N based maintenance respiration. The results agreed qualitatively with experimental data from birch and tomato plants and the agreement was considerably improved by the inclusion of maintenance respiration. Senescence and resorption as mechanisms of maximising photosynthetic production were used to predict LAI and resorption efficiency in relation to canopy N. This theory explained the observed LAI for four investigated plant species: red amaranth (*Amaranthus cruentus*), soybean (*Glycine max*), rice (*Oryza sativa*), and sorghum (*Sorghum bicolor*). Analytical expressions for forest photosynthesis, NPP, growth, LAI, root:leaf allocation and leaf N concentration were derived using a principle of maximal growth and optimisation of canopy N. Whole forest responses to N availability and atmospheric $C0_2$ were predicted from basic physiological parameters. The results agreed well with results of elevated $C0_2$ FACE experiments for sweetgum and loblolly pine trees. Finally, the findings of reduced decomposition and increased growth in response to fertilisation and elevated $C0_2$ were evaluated in the context of the global carbon balance. A simple model of the responses of global carbon fluxes and pool turnover rates combined with a future scenario of $C0_2$ entissions was subjected to a strong fertilisation effect on the boreal forest components. The results indicate that massive fertilisation could temporarily halt the rising of the atmospheric $C0_2$.

Parthiban *et al.* (2001) reported that the effect of integrated use of nitrogen (at 0, 50, 100, 150 and 200 kg/ ha), farmyard manure (FYM) at 20 tonnes/ha and biofertilizers (Azospirillum and Azotobacter, each at 2 kg/ha), on the growth and yield of globe amaranth (G. globosa) was investigated in field experiments conducted at Horticultural College and Research TnsLitute, Periyakularti, Tamil Nadu, India, during 1995-96. Twenty treatment combinations were imposed for each type of globe amatanLh (pink and white) . A maxialum number of flowers of 292.56 in pink, 282.05 in white during kharif and 334.71 in pink and 30B.35 in whiLe type during summer were recorded in FYM + Azospirillum at 200 kg N/ha. The highest flower yield of 17736 kg/ha in pink, 17132 kg/ha in white during kharif and 20287 kg/ha in pink and 18958 kg/ha in white during summer were also recorded in FYM + Azospirillum at 200 kg N/ha. However, the 200 and 150 kg levels of N/ha were statistically on 2ar with each other for flower yield.

Barrales (2000) reported that because of its high nutritional value and its ability to adapt over a wide range of environments, amaranth is an alternative for Mexican agricultural production. This work was done in Huazulco, Morelos, Mexico, in 1998, under rainfed conditions to evaluate the effect of nitrogen and phosphorus fertilization in grain production of amaranth var. Revancha. Levels of nitroaen tested were 0, 40, 80, and 120 kg/ha, and those of phosphorus were 0, 40, and 80 kg/ha. The combination of factors resulted in 12 treatments, analyzed in a randomized complete block design with three replications. TL was found that the quantity of water was the environmental factor that most influenced the low output. During the growing season rainfall was 664.8 nm, of which 11.29% fell during the stage of emergence, and it was observed that seeds were washed out. During grain fill, 57.6% of the rain fell, which was excessive and caused the inflorescences to rot. From an economic perspective, the treatment that resulted in the best grain yield was 120-00, although it is recommended that phosphorus be applied, so that the treatment that promoted the highest agronomical yields was 120 - 80.

Akanbi *et al.* (2000) reported the effect of compost (maize stove.L) and nitrogen (N) fertilizer on the growth, shoot yield and nutrient uptake of amaranth (Amaranthus cruentus L. var. $NHAC_3$) was studied over a period of two years. Twelve treatments derived from a factorial combination of four levels of compost (0, 1.5, 3.0 and 4.5t/ha) and 3 levels of fertilizer (0, 30 and 60 Kg N/ha) were carried out on a sandy loam soil. The experiment was arranged in a randomized complete block design with three replications. The application of compost and N fertilizer enhanced plant growth with respect to the controls. Plant height, stem girth, number of leaves and leaf area per plant, dry matter and shoot fresh yield were all significantly affected by different levels of compost in combination with or without N fertilizer. The highest plant height (46.O cm) and leaf area/plant (1548 cm^2) were obtained with combined application of 30 Kg N and 3.0 t/ha compost respectively. The cumulative fresh shoot yield increased with increase in compost rate up to 3.0 t/ha and there after decreased. Amaranth growth and shoot yield results indicated that this crop reacts strongly and positively to an application of compost but less strongly and inconsistently to the treatment levels N fertilizer. Nevertheless, as a result of compost application, the results indicated a decrease in the optimal levels of N fertilizer application. The treatments also have positive significant effect on N, P and K uptake. The highest N and P uptake were produced with combine application of 30 Kg N and 4.5 t/ha compost. However, there were no significant different between N uptake obtained at this rate and that of 30Kg N and 3.0 t/ha compost treatment. Therefore, 30 Kg N/ha combined with 3.0 t/ha compost appeared to be the best for optimum growth, shoot yield and nutrient uptake of 4 amaranth.

The effect of different N fertilizer rates (0, 50, 100, 150, 200, 250, 300, 350 and 400 kg/ha) on the protein content and starch characters of amaiantb (*Amaranthus spp.*) seeds was investigated during 1996 and 1997 in Chillan, Chile. Protein content varied between 16.5% in the control treatment (no N applied) and 18.4% in the 200 kg N/ha treatment. A linear regression was obtained as a response to N application. Protein yield per hectare varied between 457.2 kg/ha in the control and 973.4 kg/ha in the 300 kg N/ha treatment. A quadratic regression was obtained as a response to N applicaLion. The evaluated starch characters were not significantly affected by N fertilizer rate(Wilckens *et al.* 2000).

A field experiment was conducted on *Amaranthus tricolor* (cv. Lal sak) during the winter, summer and rainy seasons of 1996 - 97, testing 4 levels of N (0, 40, 80 and 120 kg N/ha) in Kalyani, India. Sowing during winter/rabi was best in terms of seed yield, followed by sowing during pre kharif/summer and kharif/rains. Yield components and seed yield increased with increasing N, up to 120 kg/ha. The highest seed yield of 0.45 t/ha was obtained in rabi/November sown crops with 120 kg N/ha (Das and Ghosh 1999).

Delchev (1999) reported that Amaranthus cruentus was grown as a catch crop in irrigated conditions on podzolized soil in 1986-88 at Pazardzhik, Bulgaria at row spacings of 12.5 or 25.0 cm and given 0, 70, 140, 210 or 280 kg N/ha. Optimum production conditions of 210 kg N and narrow row spacing gave 50.97 t fresh weight, 8.4 t dry weight and 96.6 kg crude protein/ha.

Moudry *et al.* (1999) studied in small-plot multifacLorial trials at Ceske Budejovice, Czech Republic in 1997-99, eight genotypes of Amaranthus (including *A. hybridus*, *A. hypochondriacus* and *A. cruentus*) were compared on acid pseudogley soil. Each genotype was sown at weekly intervals at 24 or 36 plants/ha and given 0 or 50 kg N fertilizer/ha. Some treatments had to be eliminated because of Fusarium infection. Average seed yields of all genotypes were generally increased by N application but not in each particular growing season. Seed yields were higher at the higher plant density except in 1998. Sowing in May was considered best. Average seed yields ranged from 1.31 to 2.46 t/ha with N application without significant differences between the genotypes.

Myers (1998) studied the effect of N fertilizer on amaranth (Amaranthus spp.) grain yield, yield components, and growth and development was investigated in three Missouri environments with five levels of N fertilizer (NH_4NO_3 broadcast presowing at 0, 45, 90, 135 or 180 kg N/ha) and three cultivars (Plainsman, D 136, and K 266). Averaged across cultivars and environments, N fertilizer at the top rate of 180 kg N/ha produced a yield increase of 42% relative to plots receiving no N fertilizer. Yields were consistently improved by additions of 45 and 90 kg N/ha, but additional N fertilizer above the 90 kg N/ha rate increased yield in only one out of three environments. At the one site where yield components were evaluated, yield differences were due to increases in seed number per plant, since seed weight and plant population at maturity were unaffected by N fertilizer rate. Plots with high rates of N fertilizer had later maturity, as indicated by time of flowering and seed moisture. Average moisture of seeds harvested from plots receiving 180 kg N/ha was 320 g/kg, while seeds from plots with no N fertilizer had 240 g/kg moisture. Comparing the same high-N treatment to the control with no N showed height increases of 14, 24, and 44% in the three environments. Although amaranth yield is responsive to N application, high rates of N fertilizer can negatively affect grain harvest in terms of excessive plant height, increased lodging, and delayed crop maturity.

Jhon (1992) reported that seedlings of Gomphrena globosa, grown for cut flowers, were planted on 6 June in silty loam soil with a pH of 6.8, 26.79 kg available P_20_5/ha, 316.80 kg available K_20/ha and 1.08% organic C. The effects of 3 spacings (20 X 30, 20 X 45 and 20 X 60 cm), 3 rates of N (0, 100 and 200 kg/ha) and pinching vs. non-pinching were compared. A base dressing of 25 t manure, 100 kg P_20_5 and 100 kg K_20/ha and half the N dose were applied before planting. The remaining N was top-dressed. Plant width, number of branches/plant and number and weight of flowers/plant increased significantly with wider spacing and increasing N rate. However, the total flower yield/unit area was greatest with a spacing of 20 X 30 cm. The number and weight of flowers were significantly greater in pinched than in non pinched plants. Plant height was not significantly influenced by any of the treatments.

Subhan (1989) reported that N at 0, 30, 70 and 110 kg/ha was applied to A. tricolor as a single application at sowinq, 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 FW increased with increasing N application whilst root length was reduced by high N application. The highest yields were obtained with a split application of 110 kg N/ha.

2.2 Organoleptic test

Khan (1993) reported that the white skinned color, long in length and diameter of the pod for shape and size, tasty, flavourness and fibrousness of yardlong bean were considered for judging the highest acceptability score.

According to Hamid *et al.* (1989) organoleptic test of amaranth have been done by a panel of judges on taste and cooking quality of some local and exotic germplasms. The performance of taste and cooking quality of local germplasm were better than exotic germplasm.

Abbott and Campbell (1982) studied the sensory evaluation of 20 steamed vegetables amaranth (*Amaranthus* spp.) on appearance, flavour, texture, and overall eating quality. They rated on hedonic scales by consumers sensory panels. Several entries , of *A. tricolor* had nonsignificantly lower scores than spinach (*Spinacia oleracea* L. of the *A. tricolor* entries "Chin" was the best overall and "Tampala" (most readily available entry in the U.S.) was intermediate. *A. dubius* was intermediate and *A. cruentus* entries were least acceptable .

It was observed that the red-skinned, white-fleshed, fusiform or elliptical shaped and medium sized cultivars of sweet potato placed of the list in the acceptability score (Hossain and Siddque, 1982).

However, similar type of work has been done by Villareal *et al.* (1979) and Hossain and Siddique (1982) on sweet potato and Khan (1993) on yardlong bean.

Villareal *et al.*(1979) studied the steamed roots of promising breeding lines and cultivars of sweet potato for evaluating flavor, dryness, stickiness, color and general acceptability and to determine the selection criteria that influence general acceptability. The acceptability ranking of roots varied according to the nationality of the panel members. Based on the result of step wise multiple regression analysis, it appeared that flavor and color would be good eating quality for predicting general acceptability of steamed sweet potato roots. Alcohol insoluble solids and total soluble solids after steaming contributed 85% to the variation of dryness in sweet potato roots.

Searching of literature on organoleptic test of amaranth, only a few have received. *Amaranthus tricolor* L. a high yielding and delicious strain in the yield of edible green matter, the leaves were succulent and tasty as was evident from the scoring of organoleptic tests (Kamalanathan *et al.*, 1973). They evaluating on appearance, succulence, cooking quality, fibre content and flavor.

CHAPTER 3

This chapter deals with the materials and methods that were used in executinon of the experiment.

3.1 Experimental Site

The experiment was carried out at the horticultural farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka–1207, during March to June, 2005. It is located 23.774° N latitude and 90.335° E longitude with an elevation of 8.2 meter from sea level (Anon 1989).

3.2 Soil

The soil of the experimental field belongs to the Modhupur Tract in Agroecological Zone (AEZ) 28 (UNDP, 1988). The analytical data of the soil sample collected from the experimental area were determined in the SRDI, Soil Testing Laboratory, Khamarbari, Dhaka have been presented in Appendix I.

3.3 Climate

The experimental site is situasted in subtropical zone, characterized by heavy rainfall during the months from April to September (Kharif season) and scantly rainfall during the rest of the year (Rabi season). Information regarding average monthly maximum and minimum temperature, rainfall and relative humidity, soil temperature as recorded by Bangladesh Meterological Department, during the period of study have been preasented in Appendix II.

3.4 Plant materials

Three cultivars of amaranth:

1. BARI Danta I
2. Bashpata
3. Katua

3.5 Design and layout of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) having two factors with three replications. An area of 25.4 m x 8.0 m was divided into three equal blocks. Each block was consists of 15 plots where 15 treatments were allotted randomly. Thus there were 45 unit plots altogether in the experiment. The unit plot size was 1.5 m x 1.0 m. The unit plots and blocks were separated by 0.60 m and 0.75 m respectively. Plant to plant distance 33 cm and row to row distance 30 cm. Each unit plot had three rows and each with five plants. Therefore, there were fifteen plants per unit plot.

3.6 Treatments

The experiment was designed to study the effect of cultivars and different levels of nitrogen on yield and yield contributing characters of amaranth. The experiment consisted of two factors, which are as follows:

3.6.1 Factor A

Cultivars

1. V_1 : BARI Danta 1
2. V_2 : Baspata
3. V_3 : Katua

3.6.2 Factor B:

Nitrogen levels (in the form of urea)

N_0: No application of any N fertilizer (control)

N_1: Application of N, at the rate of 87 kg/ha

N_2: Application of N, at the rate of 92 kg/ha

N_3: Application of N, at the rate of 96.6 kg/ha

N_4: Application of N, at the rate of 101.2 kg/ha

3.6.3 Treatment combination:

There were altogether fifteen treatment combinations such as:

$V_1 N_0$, $V_1 N_1$, $V_1 N_2$, $V_1 N_3$, $V_1 N_4$,
$V_2 N_0$, $V_2 N_1$, $V_2 N_2$, $V_2 N_3$, $V_2 N_4$,
$V_3 N_0$, $V_3 N_1$, $V_3 N_2$, $V_3 N_3$, $V_3 N_4$

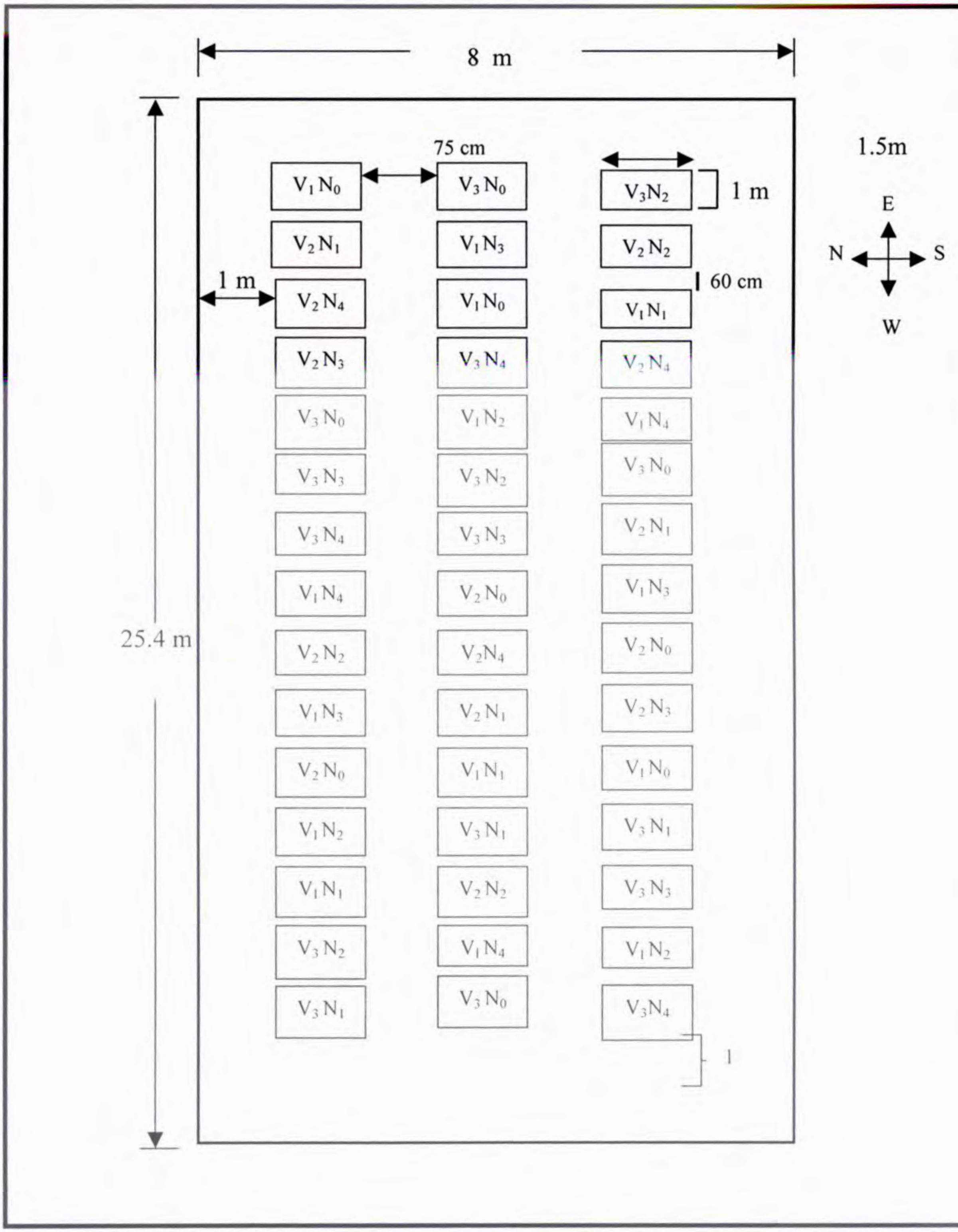

Figure 1. Field layout

3.7 Soil Analysis

The analytical data of the soil sample collected from the experimental area were determined in the SRDI, Soil Testing Laboratory, Khamarbari, Dhaka. The analytical results of the collected soil before treatment are presented in Table 1.

Table 1. Physical and chemical properties of the soil before starting the experiment

Characters	Value
Partical size analysis	
% Sand	27
% Silt	43
% clay	30
Textural class	Silty clay
p^H	6.5
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/ 100 g soil)	0.10
Available S (ppm)	45

3.8 Land preparation

The land selected to carry out the experiment was opened on 19 March 2005 with a power tiller and then it was kept open to sun for seven days prior to further ploughing. Afterwards it was prepared by ploughing and cross ploughing followed by laddering. Deep ploughing was done to have a good tilth, which necessary for getting better yield of the crop. The weeds and stubbles were removed after each laddering. Simultaneously the clods were broken and the soil was made into good tilth. The basal dose of manures, cowdung 20 tons/ha and fertilizers were mixed into the soil during final land preparation. Finally, the plot was raised by 10 cm for good drainage.

3.9 Manures, fertilizers and their methods of application

Manures, fertilizer doses and their methods of application described by Rashid (1999) as shown in table 2 were applied.

Table 2. Doses of manures, fertilizers, and their methods of application used for this experiment

Manures/ fertilizers	Dose per ha (kg)	Basal dose (kg)	Top dressing (kg)
Cowdung	20 tons/ha	Entire	----
P_2O_5	48	Entire	----
K_2O	120	Half (50%)	Rest half (50%) was applied into two equal splits at 30 and 45 days after sowing (DAS)
N_2	-	-	Total N was applied into three equal splits at 15, 30 and 45 DAS

3.10 Collection and sowing of seeds

The seeds of amaranth cultivars BARI Danta 1, Baspata and Katua were used in the experiment. The seeds were collected from Kushtia Seed Store, Dhaka. The seeds were sown in the rows of the raised bed on 29 March 2005. Row to row and plant to plant spacing were maintained 30 cm and 33 cm respectively. Two to three seeds were sown in each pit. Then the seeds were covered with fine soil by hand.

3.11 Intercultural operations

Necessary intercultural, operations were done throughout the cropping season for proper growth and development of the plant. Five to six days after germination only one healthy seedling was kept to grow in each hill and other seedlings were thinned out. The crop was irrigated as and when necessary. Weeding was done four times. Diaginon 60 EC @ 3.5 ml/L water in thrice in an interval of 10 days started soon after the appearance of insect infestation and Bavistin @ 0.02 % was sprayed 4 times at an interval of 7 days for controlling foot rot.

3.12 Harvesting

To evaluate the yield harvesting was done at 55 DAS.

3.13 Data collection

Data were recorded on the following parameters from the sample plants during the course of experiment. Ten (10) plants were sampled randomly from each unit plot for the collection of data. The plants in the outer rows and at the extreme end of the middle rows were excluded from the random selection to avoid the border effect. The data were collected at 25, 40 and 55 DAS. The following yield and yield contributing characters were considered in this study.

3.13.1 Morphology of plant

Stem color, leaf color, base color, vain color, pubescence and petiole were estimated through color chart/visual aid.

3.13.2 Yield contributing characters

3.13.2.1 Days to visible germination

First germination was appeared 3 days after sowing of seeds and was completed within 5 days of all cultivars.

3.13.2.2 Plant height (cm)

Plant height was measured in centimeter (cm) by a meter scale at 25, 40 and 55 DAS from the base (ground level) of stem up to the tip of the longest leaf. Average height of 10 plants were taken very carefully from the randomly selected plants.

3.13.2.3 Number of leaves per plant

Number of leaves per plant of 10 randomly selected plants was counted at 25, 40 and 55 DAS. All the leaves of each plant were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from counting. Calculation the average number of leaves, then average number was recorded.

3.13.2.4 Length of leaves (cm)

Length of leaves were measured in centimeter (cm) with the help of a meter scale from the base of petiole which attached with stem up to tip point of leaves and average leaf length of 10 leaves per plant were recorded from randomly selected sample plants.

3.13.2.5 Breadth of leaves (cm)

Breadth of leaves were measured in centimeter (cm) with the help of a meter scale from the middle of the leaves. Average leaf breadth of 10 leaves per plant were recorded from randomly selected sample plants.

3.13.2.6 Number of branches

Number of branches per plant of 10 randomly selected plants ware counted at 30, 50 and 70 DAS. All the branches of each plant were counted separately. Only the smallest young branches at the growing point of the plant were excluded from counting. Calculation the average number of branches, then average number was recorded.

3.13.2.7 Stem girth (cm)

To measure the girth (Diameter) of the stem a slid calipers was used. The girth of the stem was measured in centimeter after harvest at the thickened portion of the stem.

3.13.2.8 Fresh weight of leaves (g)

The leaves of selected ten plants were separated from the stem and then the triple beam balance in gm took fresh weight and average value was calculated.

3.13.2.9 Fresh weight of stem (g)

The stem of selected ten plants were cut with a knife and made as convenient pieces. Then the triple beam balance in gm took fresh weight and average value was calculated.

3.13.2.10 Leaf - stem ratio

Leaf - stem ratio was measured by the following formula

$$\text{Leaf - stem ratio} = \frac{\text{Fresh weight of stem}}{\text{Fresh weight of leaves}}$$

3.13.2.11 Weight per plant (g)

Randomly selected 10 plants were harvested from the base and then the triple beam balance in gm took fresh weight and average value was calculated.

3.13.2.12 Marketable yield per plot (kg)

Average value of randomly selected 10 plants was multiplied by total number of plants (15) per plot at final harvest.

3.13.2.13 Yield (t/ha)

The yield per hectare was calculated from the yield per plot.

3.13.3 Laboratory procedure

3.13.3.1 Percent dry matter of plant

Immediately after harvest, the leaves and stems were cleaned throughly by washing with water . Then a sample of 100 gm was taken randomly from both the leaves and stems seperately and the stems were cut into small and thin pieces. The leaves and small pieces of stem were sun dried for three days and then oven dried 72 hours at 70-80°c. Immediately after oven drying, the dried samples were weighted and dry matter content of the plants were calculated by following formula

$$\%\text{ Dry matter of stem} = \frac{\text{Constant dry weight of stem}}{\text{Fresh weight of stem}} \times 100$$

3.13.3.2 Organoleptic test

A panel of Judges consisting of 25 members were assigned to evaluate appearance crispiness, taste and flavour by organoleptic test on the basis of aceptibility : Highly Acceptable (HA=7), Moderately Acceptable (MA=5) and Unacceptable (UA=2) for fibre, taste and flavour (sweetness, crispiness and sourness) and appearance (color) respectively (Villarel *et al.*, 1979).

3.13.3.3 Convertion of organoleptic score

Highly acceptable score: Panelist score x 7

Moderately acceptable score: Panelist score x 5

Unacceptable score: Panelist score x 2

3.14 Statistical analysis

The recorded data on different parameters were statistically analyzed by using MSTAT software to find out the significance of variation resulting from the experimental treatments. The mean values for all the treatments was calculated and the analysis of variance for most of the characters was accomplihsed by 'F'variance test. The significance of difference between pair of means was tested at 5% and 1% level of probabilty (Gomez and Gomez, 1984).

CHAPTER 4

The results obtained from the present study in respect of varietal performance, yield and yield components, quality and organoleptic test are presented and discussed characterwise under separate heading in this chapter. The results on the morphological characters are presented in table 3 to 9, figure 2 to 3 and plate 1, 2, 3, 4, 5, 6, 7 and discussions are given in the following headings.

4.1 MORPHOLOGY OF PLANT

4.1.1 Stem colour

The stem of different cultivars showed a great variation in their stem colour (Table 3). The skin colour of the cultivars BARI danta 1 was pale red and that of Baspata and Katua were light green (Plate 5, 6 and 7).

Table 3. Morphological characters of three cultivars of amaranth.

Cultivars	Stem colour	Leaf colour	Base colour	Vein colour	Pubescence	Petiole colour
BARI danta-1	Pale red	Pale red	Pale red	Pale red	Present	Pale red
Baspata	Light green	Green	Light green	Light green	Present	Green
Katua	Light green	Light green	Light green	Light green	Present	Green

Mohideen *et al.* (1983) observed the variation in stem colour as brown, green, orange, yellow green, yellow with purple tint and yellow green crimson. Hamid *et al.* (1989) reported stem colour of amaranth varied from green to reddish green and red to deep red colour. The result of the present study were close to thesefindings. These variation in stem colour of amaranth may be due to their genetic constitution.

4.1.2 Leaf colour

The colour of the leaves of amaranth cultivars under study varied from light green to pale red (Table 3). The leaf colour of BARI danta 1 was pale red, Bashpata is green and katua is light green in colour (Plate 1, 2, 3 and 4).

Campbell *et al.* (1982) classify the leaf colour of amaranth as green, dark green, red colour and medium green. Hamid *et al.* (1989) found that leaf colour varied from light green to green and reddish to red of different lines. The present findings were very close to that findings.

4.1.3 Base colour

The colour differences were also observed in the case of leaf base also. It varied from light green to pale red (Table 3). The base colour of the cultivars BARI danta 1 was pale red and that of Bashpata and katua were light green in color.

4.1.4 Vein colour

The colour differences were also observed in the case of the leaf vein (Table 3). The cultivar under study varied from light green to pale red in vein colour (Table 3). Cultivars BARI danta 1 was pale red and that of Bashpata and katua were light green in color.

4.1.5 Pubescence

The pubescence were present in the cultivars BARI danta 1, Bashpata and katua (Table 3).

Plate 1. Leaves of Bashpata

Plate 2. Leaves of BARI danta 1

Plate 3. Leaves of Katua

Plate 4. Leaves of three cultivars

Plate 5. Effect of different levels of N on plant height of BARI danta-1

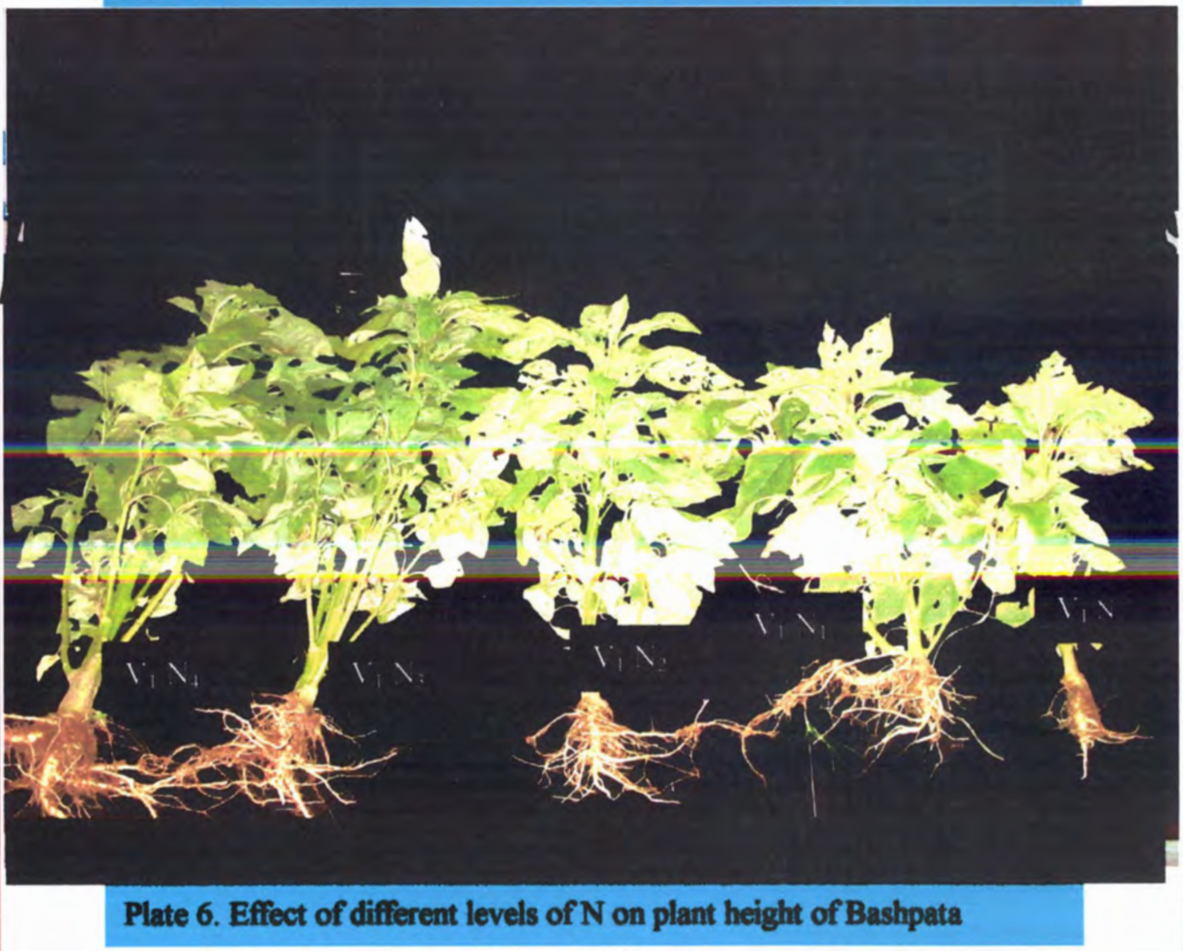

Plate 6. Effect of different levels of N on plant height of Bashpata

Plate 7. Effect of different levels of N on plant height of Katua

4.2 EFFECT OF NITROGEN ON YIELD CONTRIBUTING CHARACTERS OF AMARANTH

4.2.1 Plant height

The five levels of nitrogen showed significant variation in respect of plant height at 25 DAS (Figure 2). However, some differences were observed among the different levels of nitrogen in plant height which ranging from 12.4to 17.5 cm. The maximum plant height (17.5 cm) was recorded in plots where highest level of N (102 kg/ha) was applied while the minimum plant height (12.4 cm) was found in control treatment.

The five levels of nitrogen showed significant variation in respect of plant height at 50 DAS (Figure 2). The maximum plant height (39.0 cm) was recorded in plots where highest level of N (102 kg/ha) was applied while the minimum plant height (25.2 cm) was found in control treatment.

Significant variation in plant height was observed at 70 DAS due to application of different levels of N to the soil (Figure 2). The maximum plant height (94.7 cm) was obtained from highest level of N (102 kg/ha), while the minimum plant height (54.7 cm) was found in control treatment.

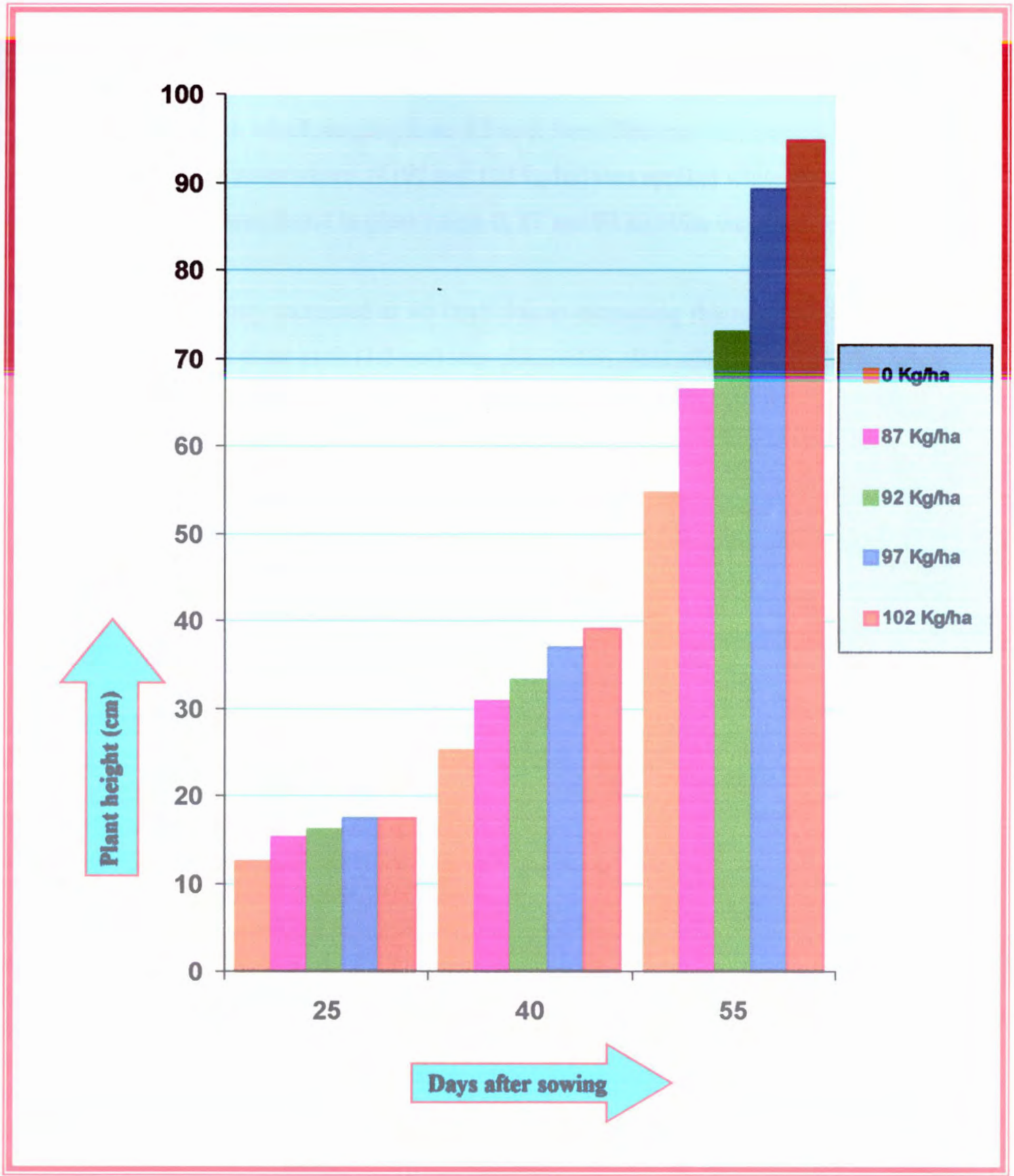

Figure 2. Effect of different levels of N on plant height at different days after sowing (DAS)

4.2.2 Plant girth

The five levels of nitrogen showed significant variation in respect of plant girth at 25 DAS (Table 4). However, some differences were observed among the different levels of nitrogen in plant girth which ranging from 0.5 to 0.6 cm. The maximum plant girth (0.6 cm) was recorded in plots where N (97 and 102 kg/ha) was applied while the minimum plant girth (0.5 cm) was found in plots where 0, 87 and 92 kg N/ha were applied.

Plant girth significantly increased at 40 DAS due to increasing the rates of N to the soil (Table 4). Maximum plant girth (1.5 cm) was obtained in plots where 102 kg N /ha while the minimum plant girth (1.1cm) was found in control treatment.

The five levels of nitrogen showed significant variation in respect of plant girth at 55 DAS (Table 4). Maximum plant girth (3.0 cm) was obtained in plots where the highest N level 102 kg /ha was applied while the minimum plant girth (1.9 cm) was found in control treatment.

4.2.3 Leaf length

The five levels of nitrogen did not show significant variation in respect of leaf length at 25 DAS (Table 4). The maximum leaf length (8.6 cm) was recorded at the highest N level 102 kg/ha and minimum leaf length (7.1 cm) was recorded in control treatment.

Non significant variation in respect of leaf length was recorded at 40 DAS (Table 4). The maximum leaf length (14.9 cm) was recorded at the highest N level 102 kg/ha and minimum leaf length (12.2 cm) was found in control treatment.

The five levels of nitrogen did not show significant variation in respect of leaf length at 55 DAS (Table 4). The maximum leaf length (17.9 cm) was recorded at the highest N level 102 kg/ha and minimum leaf length (15.5 cm) was found in control treatment.

4.2.4 Leaf breadth

The five levels of nitrogen did not show significant variation in respect of leaf breadth at 25 DAS (Table 4). The maximum leaf breadth (6.1 cm) was recorded at the highest N level 102 kg/ha and minimum leaf breadth (5.1 cm) was found in control treatment.

Non significant variation in respect of leaf breadth was recorded at 40 DAS (Table 4). The maximum leaf breadth (8.5 cm) was recorded at the highest N level 102 kg/ha and minimum leaf breadth (7.6 cm) was found in control treatment.

The five levels of nitrogen did not show significant variation in respect of leaf breadth at 55 DAS (Table 4). The maximum leaf breadth (10.1 cm) was recorded at the highest N level 102 kg /ha and minimum leaf breadth (8.5 cm) was found in control treatment.

4.2.5 Number of leaves

The five levels of nitrogen showed significant variation in respect of number of leaves per plant at 25 DAS (Table 4). The maximum number of leaves per plant (35.6) were obtained in plots where the highest level of N (102 kg/ha) was applied while the minimum number of leaves per plant (21.0) were found in control treatment.

The five levels of nitrogen showed significant variation in respect of number of leaves per plant at 40 DAS (Table 4). The maximum number of leaves per plant (87.0) were recorded in plots where the highest level of N (102 kg/ha) was applied while the minimum number of leaves per plant (46.6) were found in control treatment.

Significant variation in number of leaves per plant were observed at 55 DAS due to application of different levels of N to the soil (Table 4). The maximum number of leaves per plant (223.4) were obtained from the highest level of N (102 kg/ha), while the minimum number of leaves per plant (76.5) were found in control treatment.

4.2.6 Number of branches per plant

The five levels of nitrogen showed significant variation in respect of number of branches per plant at 25 DAS (Table 4). The maximum number of branches per plant (2.3) wereobtained in plots where the highest level of N (102 kg/ha) was applied while the minimum number of branches per plant (0.8) were found in control treatment.

The five levels of nitrogen showed significant variation in respect of number of branches per plant at 40 DAS (Table 4). The maximum number of branches per plant (6.2) were recorded in plots where the highest level of N (102 kg/ha) was applied while the minimum number of branches per plant (4.4) were found in control treatment.

Significant variation in number of branches per plant was observed at 55 DAS due to application of different levels of N to the soil (Table 4). The maximum number of branches per plant (12.3) were obtained from the highest level of N (102 kg/ha), while the minimum number of branches per plant (5.8) were found in control treatment.

The result indicated that the number of branches increased has a positive relation with the nitrogen levels and ultimately increased the total yield. It may be mentioned that lateral branching influenced yield per plant.

Table 4. Effect of nitrogen on yield contributing characters of Amaranth

DAS	Nitrogen levels	Characters					
		Plant height (cm)	Plant girth (cm)	Leaf length (cm)	Leaf breadth (cm)	Number of leaves per plant	Number of branches per plant
25	N_0	12.4	0.5	7.1	5.1	21.0	0.8
	N_1	15.3	0.5	7.5	5.6	25.5	1.3
	N_2	16.1	0.5	8.1	5.8	28.6	1.8
	N_3	17.4	0.6	8.5	6.0	29.1	2.2
	N_4	17.5	0.6	8.6	6.1	35.6	2.3
40	N_0	25.2	1.1	12.2	7.6	46.6	4.4
	N_1	30.8	1.2	13.6	8.3	63.1	5.2
	N_2	33.3	1.4	14.3	8.2	68.9	5.3
	N_3	36.9	1.4	14.7	8.4	83.4	6.0
	N_4	39.0	1.5	14.9	8.5	87.0	6.2
55	N_0	54.7	1.9	15.5	8.5	76.5	5.8
	N_1	66.4	2.1	16.2	9.0	119.6	8.5
	N_2	73.1	2.3	17.1	9.3	143.9	9.2
	N_3	89.2	2.6	17.8	9.4	198.2	11.5
	N_4	94.7	3.0	17.9	10.1	223.4	12.3
Level of significance		**	**	NS	NS	**	**
F Value		14.30	13.03	1.25	0.81	45.82	6.24

** Significant at 1% level, * Significant at 5% level, NS– Non Significant

N_0 = 0 kg/ha

N_1 = 87kg/ha

N_2 = 92kg/ha

N_3 = 97 kg/ha

N_4 = 102 kg/ha

DAS - Days after sowing

4.3 EFFECT OF CULTIVAR ON YIELD CONTRIBUTING CHARACTERS OF AMARANTH

4.3.1 Plant height

Significant variation was observed among the cultivars in respect of plant height at 25 DAS (Table 5). The maximum plant height was recorded from Bashpata (18.4 cm) which was followed by BARI danta 1 (16.1 cm). The minimum plant height was recorded in Katua (12.7 cm).

Significant variation was observed among the cultivars in respect of plant height at 40 DAS (Table 5). The maximum plant height was recorded from Bashpata (37.9 cm) which was followed by BARI danta 1 (32.2 cm). The minimum plant height was recorded in Katua (29.7 cm).

Among the three cultivars significant variation was observed in plant height at 55 DAS (Table 5). The maximum plant height was recorded from BARI danta 1 (83.1 cm) which was significantly superior than the others. The plants of Katua were produced significantly minimum (63.1 cm) plant height.

The trend of increasing the plant height in each observation was not similar to all stages of observation. Hamid *et al.* (1989) reported that plant height of some exotic and local lines varied from 70.20 to 131.60 cm at 49 th DAS.

Mohideen *et al.* (1985) reported that plant height of Co.3 was ranges from 90 to 100 cm. Again, Mohideen et al. (1983) obtained the plant height of grain amaranth of different cultivars ranges from 59.70 to 189.50 cm. Rajagopal et al. (1977) observed the plant height of Co. I at 35 DAS was 41.50 cm, 40 DAS was 56.30 cm and 75 DAS was 172.20 cm. The present findings were slightly lower than the previous report. It appears due to ecological variation or the inherent capability of different genotypes.

4.3.2 Plant girth

Significant variation was observed among the cultivars in respect of plant girth at 25 DAS (Table 5). The maximum plant girth was recorded from BARI danta 1 (0.6 cm) which was followed by Bashpata (0.5 cm). The minimum plant girth was recorded in Katua (0.5 cm).

Significant variation was observed among the cultivars in respect of plant girth at 40 DAS (Table 5). The maximum plant girth was recorded from BARI danta 1 (1.5 cm). The minimum plant girth was recorded in Bashpata and Katua (1.2 cm).

Among the three cultivars significant variation was observed in plant girth at 55 DAS (Table 5). The maximum plant girth was recorded from Bashpata (2.6 cm) which was significantly superior than the others. The plants of Katua were produced significantly minimum (2.2 cm) plant girth.

Hamid *et al.* (1989) stated that stem diameter of the local germplasm were varied from 5.30 to 9.30 mm at 49 DAS. This stem diameter differences might be due to different genotypes and ecological variation of the two localities.

4.3.3 Leaf length

Among the three cultivars significant variation was observed in leaf length at 25 DAS (Table 5). The maximum leaf length was recorded from Katua (8.5 cm) which was significantly superior than the others. The plants of BARI danta 1 were produced significantly minimum (7.0 cm) leaf length.

Significant variation was observed among the cultivars in respect of leaf length at 40 DAS (Table 5). The maximum leaf length was recorded from Katua (16.3 cm) which was followed by Bashpata (13.8 cm). The minimum leaf length was recorded in BARI danta 1 (11.7 cm).

Significant variation was observed among the cultivars in respect of leaf length at 55 DAS (Table 5). The maximum leaf length was recorded from Bashpata (19.3 cm) which was followed by Katua (17.5 cm). The minimum leaf length was recorded in BARI danta 1 (13.8 cm).

Rajagopal *et al.* (1977) observed the length of leaves in two cultivars at 35 DAS was 8.80 to 9.20 cm and 40 DAS was 9.80 to 10.20 cm. Mohideen *et al.* (1985) reported that the length of Co. 3 was 4.50 cm. The variation in leaf length among the genotypes as obtained in the study may be attributed as their genetic make-up.

4.3.4 Leaf breadth

Significant variation was observed among the cultivars in respect of leaf breadth at 25 DAS (Table 5). The maximum leaf breadth was recorded from Bashpata (5.9 cm) which was followed by BARI danta 1 (5.8 cm). The minimum leaf breadth was recorded in Katua (5.5 cm).

Significant variation was observed among the cultivars in respect of leaf breadth at 40 DAS (Table 5). The maximum leaf breadth was recorded from Bashpata (8.4 cm) which was followed by BARI danta 1(8.3 cm). The minimum leaf breadth was recorded in Katua (7.7 cm).

Among the three cultivars significant variation was observed in leaf breadth at 55 DAS (Table 5). The maximum leaf breadth was recorded from BARI danta 1 (10.2 cm) which was significantly superior than the others. The plants of Katua were produced significantly minimum (8.1 cm) leaf breadth.

Rajagopal *et al.* (1977) obtained the breadth of leaves of two cultivars at 35 DAS was 4. 10 to 5.90 cm and 40 DAS was 5. 10 to 7.60 cm.

4.3.5 Number of leaves per plant

Higher increasing tendency of the number of leaves per plant observed in different cultivars of amaranth at different stages.

Significant variation was observed among the cultivars in respect of number of leaves per plant at 25 DAS (Figure 3). The maximum number of leaves per plant was recorded from Katua (46.1) which was followed by Bashpata (19.9). The minimum number of leaves per plant was recorded in BARI danta 1 (18.7).

Significant variation was observed among the cultivars in respect of number of leaves per plant at 40 DAS (Figure 3). The maximum number of leaves per plant was recorded from Katua (100.4) which was followed by Bashpata (64.9). The minimum number of leaves per plant was recorded in BARI danta 1 (44.2).

Among the three cultivars significant variation was observed in number of leaves per plant at 55 DAS (Figure 3). The maximum number of leaves per plant was recorded from Katua (217.0) which was significantly superior than the others. The plants of BARI danta 1 were produced significantly minimum (63.3) number of leaves per plant.

Hamid, *et al*. (1989) found that the numbers of leaves per plant in local cultivars at 49 th DAS was ranges from 72.3 to 162. The present study at 55 DAS ranged from 32.4 to 56.7 which was much lower than the previous report. This variation may be due to difference of cultivars used in the present study.

4.3.6 Number of branches per plant

There was significant variation among the three cultivars in number of branches per plant at 25, 40 and 55 DAS (Table 5). The maximum number of branches per plant were recorded from Katua 3.2 at 25 DAS, 9.5 at 40 DAS and 18.4 at 55 DAS while BARI danta 1 produced no branch.

The result indicated that more lateral branches produced more yield per plant.

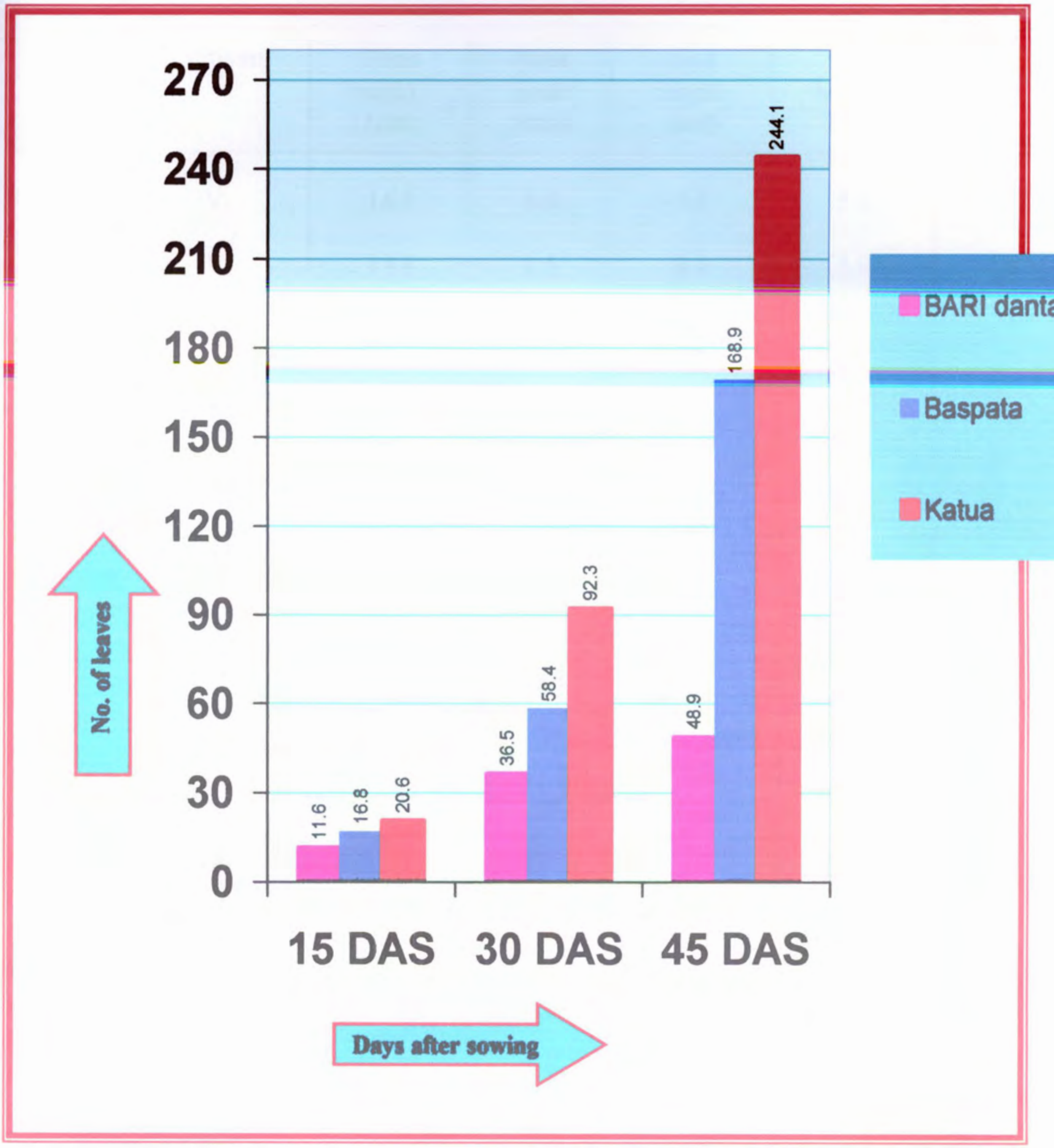

Figure 3. Effect of cultivars on number of leaves at different days after sowing (DAS)

Table 5. Effect of cultivar on yield contributing characters of Amaranth

DAS	Cultivars	Characters				
		Plant height (cm)	Plant girth (cm)	Leaf length (cm)	Leaf breadth (cm)	Number of branches
25	V_1	16.1	0.6	7.0	5.8	0.0
	V_2	18.4	0.5	8.4	5.9	1.8
	V_3	12.7	0.5	8.5	5.5	3.2
40	V_1	32.2	1.5	11.7	8.3	0.0
	V_2	37.9	1.2	13.8	8.4	6.8
	V_3	29.7	1.2	16.3	7.7	9.5
55	V_1	83.1	2.3	13.8	10.2	0.0
	V_2	80.7	2.6	19.3	9.5	10.1
	V_3	63.1	2.2	17.5	8.1	18.4
Level of significance		**	**	**	*	**
F Value		19.90	9.74	13.54	3.43	104.36

** Significant at 1% level, * Significant at 5% level, NS– Non Significant

V_1 = BARI danta 1

V_2 = Bashpata

V_3 = Katua

DAS - Days after sowing

4.4 COMBINED EFFECT OF CULTIVAR AND NITROGEN ON THE YIELD AND YIELD CONTRIBUTING CHARACTERS

The combined effect of cultivar and nitrogen on the yield and yield components of okra is presented in table 6 and 7.

4.4.1 Plant height

Plant height was significantly increased with increasing the nitrogen level at 25 DAS (Table 6). The maximum plant height (20.9 cm) was recorded from Bashpata at 97 kg N/ha while the minimum plant height (8.9 cm) was recorded from Katua at control treatment.

Significant variation was observed in plant height at 40 DAS (Table 6). Bashpata produced the maximum plant height (43.8 cm) at 97 kg N/ha while the minimum plant height (22.3 cm) was recorded from Katua at control treatment.

Significantly plant height was increased at 55 DAS (Table 6).The maximum plant height (109.7 cm) was recorded from Bashpata at 97 kg N/ha and minimum plant height (50.3 cm) was observed at control treatment by Katua.

4.4.2 Plant girth

Plant girth was non significant with increasing the nitrogen levels at 25, 40 and 55 DAS (Table 6). Plant girth varies from 0.4 to 0.6 cm at 25 DAS, 0.9 to 1.7 cm at 40 DAS and 1.8 to 2.9 cm at 55 DAS.

4.4.3 Leaf length

Significant variation was observed in leaf length at 25 DAS (Table 6) . The maximum leaf length (9.6 cm) was recorded from Katua at the highest level of N 102 kg/ha while the minimum leaf length (6.2 cm) was recorded from BARI danta 1 at control treatment.

Significant variation was observed in leaf length at 40 DAS (Table 6) . The maximum leaf length (17.8 cm) was recorded from Katua at the highest level of N 102 kg/ha while the minimum leaf length (10.6 cm) was recorded from BARI danta 1 at control treatment.

Significant variation was observed in leaf length at 55 DAS (Table 6) . The maximum leaf length (20.1 cm) was recorded from Bashpat at 97 kg N/ha while the minimum leaf length (12.0 cm) was recorded from BARI danta 1 at control treatment.

4.4.4 Leaf breadth

Significant variation was observed in leaf breadth at 25 DAS (Table 7). The maximum leaf breadth (6.3 cm) was recorded from BARI danta 1 at the highest level of N 102 kg/ha. The minimum leaf breadth (4.3 cm) was recorded from Katua at control treatment.

Significant variation was observed in leaf breadth at 40 DAS (Table 7) . The maximum leaf breadth were recorded from (9.1 cm) by Bashpata at (97 and 102 kg N/ha). The minimum leaf breadth (7.4 cm) was observed by Bashpata at control treatment.

Significant variation was observed in leaf breadth at 55 DAS (Table 7). The maximum leaf breadth (11.6 cm) was recorded from BARI danta 1 at the highest level of N 102 kg/ha. The minimum leaf breadth (6.4 cm) was observed by Katua at control treatment.

4.4.5 Number of branches per plant

Significant variation was observed in number of branches per plant at 25, 40 and 55 DAS (Table 7). The maximum number of branches per plant were recorded from Katua 4.3 at 25 DAS, 11.5 at 40 DAS and 24.3 at 55 DAS when the highest N level (102 kg/ha) was applied. BARI danta 1 did not show branching in all treatments.

4.4.6 Number of leaves per plant

Significant variation was observed in number of leaves per plant at 25 DAS (Table 7). The maximum number of leaves per plant (62.6) was recorded from Katua at the highest level of N 102 kg/ha. The minimum number of leaves per plant (15.7) was recorded from BARI danta 1 at control treatment.

Significant variation was observed in number of leaves per plant at 40 DAS (Table 7) . The maximum number of leaves per plant (134.6) were recorded from Katua at the highest level of N 102 kg/ha. The minimum number of leaves per plant (32.2) was recorded from BARI danta 1 at control treatment.

Significant variation was observed in number of leaves per plant at 55 DAS (Table 7). The maximum number of leaves per plant (370.8) was recorded from Katua at the highest level of N 102 kg/ha. The minimum number of leaves per plant (47.2) was observed by BARI danta 1 at control treatment.

Table 6. Combined effect of cultivar and nitrogen on plant height, plant girth and leaf length of Amaranth

Treatment combination	Plant height (cm)			Plant girth (cm)			Leaf length (cm)		
	25 DAS	40 DAS	55 DAS	25 DAS	40 DAS	55 DAS	25 DAS	40 DAS	55 DAS
$V_1 N_0$	13.3	25.5	62.3	0.6	1.3	1.8	6.2	10.6	12.0
$V_1 N_1$	15.2	30.2	75.8	0.4	1.4	2.2	6.5	11.5	13.6
$V_1 N_2$	16.3	33.7	82.1	0.6	1.6	2.5	7.0	11.8	14.1
$V_1 N_3$	17.6	34.9	89.3	0.6	1.7	2.6	7.6	12.4	14.5
$V_1 N_4$	18.4	37.1	105.8	0.6	1.7	2.8	7.8	12.5	15.0
$V_2 N_0$	15.1	27.8	51.7	0.6	1.0	2.1	8.1	12.0	17.8
$V_2 N_1$	18.3	36.3	66.1	0.5	1.3	2.3	8.3	13.8	19.5
$V_2 N_2$	18.9	40.1	77.3	0.5	1.3	2.5	8.5	14.1	19.5
$V_2 N_3$	20.9	43.8	109.7	0.6	1.4	2.8	8.8	14.9	20.1
$V_2 N_4$	19.2	41.6	99.1	0.5	1.4	3.3	8.6	14.6	20.0
$V_3 N_0$	8.9	22.3	50.3	0.4	0.9	1.9	7.0	14.1	16.7
$V_3 N_1$	12.5	26.1	57.3	0.5	1.1	1.9	7.7	15.5	18.3
$V_3 N_2$	13.1	29.7	59.9	0.5	1.4	2.1	9.0	17.2	15.1
$V_3 N_3$	13.9	32.1	68.8	0.5	1.3	2.4	9.2	17.0	18.8
$V_3 N_4$	15.1	38.5	79.3	0.6	1.4	2.9	9.6	17.8	18.7
Level of significance	**	**	**	NS	NS	NS	*	*	*
F Value	1.88	1.20	3.15	1.10	2.11	0.5	4.34	2.78	5.51

** Significant at 1% level, * Significant at 5% level, NS– Non Significant.

V_1 = BARI danta 1, V_2 = Bashpata, V_3 = Katua

N_0= Control, N_1= 87 kg/ha, N_2= 92 kg/ha, N_3= 97 kg/ha, N_4= 102 kg/ha. DAS – Days after sowing

Table 7. Combined effect of cultivar and nitrogen on leaf breadth, number of branches per plant and number of leaves per plant of Amaranth

Treatment combination	Leaf l breadth (cm)			Number of branches per plant			Number of leaves per plant		
	25 DAS	40 DAS	55 DAS	25 DAS	40 DAS	55 DAS	25 DAS	40 DAS	55 DAS
$V_1 N_0$	5.3	8.0	9.4	0.0	0.0	0.0	15.7	32.2	47.2
$V_1 N_1$	5.7	8.5	9.3	0.0	0.0	0.0	18.3	40.1	58.6
$V_1 N_2$	5.9	8.5	10.0	0.0	0.0	0.0	18.9	45.3	63.1
$V_1 N_3$	6.1	8.6	10.7	0.0	0.0	0.0	19.7	49.9	69.3
$V_1 N_4$	6.3	8.3	11.6	0.0	0.0	0.0	21.1	53.7	78.4
$V_2 N_0$	5.7	7.4	9.2	1.1	5.1	3.7	16.7	47.6	97.7
$V_2 N_1$	5.7	8.4	10.3	1.1	6.8	8.3	19.1	59.7	151.3
$V_2 N_2$	6.0	8.4	9.3	2.8	6.6	11.0	19.9	64.3	178.4
$V_2 N_3$	6.2	9.1	9.2	1.9	8.4	14.7	20.7	80.1	234.9
$V_2 N_4$	6.0	9.1	9.9	2.3	7.2	12.6	23.1	72.9	221.1
$V_3 N_0$	4.3	7.5	8.5	1.5	8.2	13.7	30.7	60.1	84.7
$V_3 N_1$	5.5	8.0	8.3	2.8	9.1	17.3	39.3	89.7	148.9
$V_3 N_2$	5.7	7.7	6.4	3.9	9.0	16.7	47.1	97.3	190.3
$V_3 N_3$	5.8	7.9	8.5	3.5	9.8	20.0	50.9	120.4	290.6
$V_3 N_4$	6.1	7.7	8.8	4.3	11.5	24.3	62.6	134.6	370.8
Level of significance	*	*	*	**	**	*	**	**	**
F Value	0.57	2.64	2.94	6.18	2.79	2.26	1.94	1.02	2.24

** Significant at 1% level, * Significant at 5% level, NS– Non Significant. V_1 = BARI danta 1, V_2 = Bashpata, V_3 = Katua
N_0= Control, N_1= 87 kg/ha, N_2= 92 kg/ha, N_3= 97 kg/ha, N_4= 102 kg/ha. DAS – Days after sowing

4.4.7 Fresh weight of leaves per plant

The cultivars showed wide range of differences of weight of leaves per plant (Table 8). Significant variation was observed at final harvest (55 DAS) of different treatments.The maximum fresh weight of leaves per plant was found from Katua (274.7g) at 102 kg N/ha which was significantly higher than any other treatments. The minimum fresh weight of leaves per plant was obtained from the Bashpata (60.1g) at control treatment on the other hand BARI danta 1 produced 113.2 g and Bashpata produced 174.3 g at the highest level of N 102 kg/ha.

Rajagopal *et al.* (1977) observed the weight of leaves per plant were 98 to 120 g at 35 DAS and 110 to 140 g at 40 DAS. The weight of leaves of the present study was nearly similar to the previous report.

4.4.8 Fresh weight of stem per plant

Significant difference among the treatments were observed for fresh weight of stem per plant (Table 8). At final harvest (55 DAS) the maximum fresh weight of stem per plant recorded from Bashpata (471.4g) at 97 kg N/ha, followed by Katua (381.2 g) and BARI danta 1 (207.1 g) at 102 kg N/ha. The minimum fresh weight of stem per plant was obtained from Bashpata (50.5 g) at control treatment.

Rajagopal *et al.* (1977) reported that weight of stem per plant was 220 to 270 g at 40 DAS. The present result were comparatively higher than previous study which may be due to either differences in genotypes or to the variation of different N levels.

4.4.9 Leaf-Stem ratio

Significant variation was found among the treatments for leaf-stem ratio at 55 DAS. The recorded data showed the increasing trend of leaf-stem ratio with increasing the nitrogen levels (Table 8).The maximum leaf-stem ratio was found from Bashpata (1:1.89) at 97 kg N/ha and the minimum was found from Bashpata (1:0.84) at control treatment.

Campbell and Abbott (1982) reported that leaf: stem ratio varied from 1.20 to 9.70 in twenty amaranth cultivars.

Mohideen *et* al. (1985) stated that the leaf stem: ratio was 2.00 in C0.3 amaranth. Rajagopal *et* al. (1977) observed leaf:stem ratio on amaranth was 0.90 to 8.20 at 35 DAS and 0.50 to 10.20 at 40 DAS.

Our present findings are much lower than the previous observations. This may be assumed due to different level of N or due to the differences in the genetic make-up of the cultivar.

4.4.10 Fresh weight per plant

The fresh weight per plant of three cultivars differed significantly at all treatments (Table 8). Maximum fresh weight per plant at 55 DAS was recorded from Bashpata (721.0 g) at 97 kg N/ha followed by Katua (655.9 g) and BARI danta 1 (340.3 g) at the highest level of N (102 kg/ha). The minimum fresh weight per plant was found from Bashpata (110.6 g) at control treatment.

4.4.11 Dry weight per plant

The dry weight per plant of three cultivars differed significantly at all treatments (Table 8). Maximum dry weight per plant at 55 DAS was recorded from Katua (109.9 g) at the highest level of N (102 kg/ha) followed by Bashpata (109.4 g) at 97 kg N/ha and BARI danta 1 (39.1 g) at 102 kg/ha. The minimum dry weight per plant was found from BARI danta 1 (20.0 g) at control treatment.

4.4.12 % Dry matter

Significant variation was found among the treatments for % Dry matter at 55 DAS. The recorded data showed maximum % Dry matter was from Katua (19.13) at control treatment (Table 8) and the minimum was found from BARI danta 1 (12.21) at the highest level of N (102 kg/ha).

4.4.13 Marketable yield per plot

Considering the final observation at 55 DAS (Table 8) the maximum yield per plot was obtained from Bashpata (10.8 kg) at 97 kg N/ha which was closely followed by Katua (9.8 kg) at 102 kg N/ha and BARI danta 1 (5.1 kg) at 102 kg N/ha. The minimum yield per plot (1.7 kg) was found from Bashpata at control treatment .

4.4.14 Yield per hectare (t/ha)

Variation of yield per hectare was higher due to different levels of N (Table 8). Significant differences was found in final harvest at 55 DAS. It ranges from 11.1 to 72.1 ton per hectare. Cultivar Bashpata (72.1 t/ha) showed the maximum yield at 97 kg N/ha which was closely followed by Katua (65.6 t/ha) and BARI danta 1 (34.0 t/ha) at the highest N level 102 kg/ha. The minimum yield was found from Bashpata (11.1 t/ha) at control treatment.

Table 8. Combined effect of cultivar and nitrogen on fresh weight of leaf, fresh weight of stem, leaf-stem ratio, fresh weight per plant, dry weight per plant, % dry matter, marketable yield per plot and marketable yield/ha of Amaranth

Treatment combination	Characters							
	Fresh weight of leaf (g)	Fresh weight of stem (g)	Leaf-stem ratio	Fresh weight per plant (g)	Dry weight per plant (g)	% Dry matter	Marketable yield per plot (kg)	Marketable yield/ha (t)
$V_1 N_0$	68.0	74.5	1:1.10	142.5	20.0	14.04	2.1	14.3
$V_1 N_1$	73.7	100.2	1:1.36	173.9	23.6	13.57	2.6	17.4
$V_1 N_2$	91.2	131.8	1:1.45	223.0	28.9	12.96	3.6	22.9
$V_1 N_3$	97.3	148.3	1:1.52	245.6	32.3	13.15	3.4	23.9
$V_1 N_4$	113.2	207.1	1:1.83	320.3	39.1	12.21	5.1	34.0
$V_2 N_0$	60.1	50.5	1:0.84	110.6	18.0	16.27	1.7	11.1
$V_2 N_1$	106.0	142.7	1:1.35	248.7	42.0	16.89	3.7	24.9
$V_2 N_2$	136.8	145.9	1:1.07	282.7	49.8	17.62	4.2	28.2
$V_2 N_3$	249.6	471.4	1:1.89	721.0	109.4	15.57	10.8	72.1
$V_2 N_4$	174.3	301.8	1:1.70	476.1	73.7	15.78	7.1	47.6
$V_3 N_0$	67.3	82.7	1:1.23	150.0	28.7	19.13	2.3	15.0
$V_3 N_1$	116.2	123.2	1:1.06	239.4	40.1	16.75	3.7	25.1
$V_3 N_2$	131.9	134.7	1:1.02	266.6	46.8	17.55	3.8	25.5
$V_3 N_3$	179.8	188.2	1:1.05	368.0	60.9	16.54	5.5	36.8
$V_3 N_4$	274.7	381.2	1:1.39	655.9	109.9	16.78	9.8	65.6
Level of significance	**	**	*	**	**	**	**	**
F Value	19.90	14.30	1.18	9.73	13.03	1.16	13.54	62.88

** Significant at 1% level, * Significant at 5% level, NS– Non Significant.
V_1 = BARI danta 1, V_2 = Bashpata, V_3 = Katua
N_0= Control, N_1= 87 kg/ha, N_2= 92 kg/ha, N_3= 97 kg/ha, N_4= 102 kg/ha.

4.4.16 ORGANOLEPTIC TEST OF THREE CULTIVARS OF AMARANTH

The organoleptic test was carried out on different parameters. A panel of 100 judges of 25-45 years age group evaluated it. All panel members were the teachers, students and staff of Sher-e-Bangla Agricultural University (SAU), Dhaka. Consumer acceptability of amaranth depends on appearance viz. color, size and on taste of cooked amaranth viz. fibre, crispiness, sweetness and sourness. For observing acceptability of amaranth a questionnaire (appendix III) and amaranth samples were served among the teachers, students and staff of the university.

The results of the preferential comments from the panelist have been summarized, when the preferential comments were converted into acceptability scores (table 8 and appendix IV).

4.4.16.1 Scoring for acceptability

Scoring for acceptability was made to the following scale, as suggested by Villareal *et al.* (1979), Hossain and Siddique (1982) and Khan (1993).

- 7 for each highly acceptable comment
- 5 for each slightly acceptable comment
- 2 for each unacceptable comment

Table 9. Acceptability score of three amaranth cultivars from organoleptic test

Parameters	Cultivars								
	BARI danta 1			Bashpata			Katua		
	HA	MA	UA	HA	MA	UA	HA	MA	UA
Color	420	160	16	588	60	8	448	160	8
Sweetness	420	180	8	448	140	16	336	220	16
Sourness	644	40	0	644	20	8	448	120	24
Crispiness	560	60	16	588	48	8	280	200	40
Fibre	504	120	8	560	48	16	140	180	44
Total	2548	560	48	2828	340	56	1652	880	176

Convertion of organoleptic score

Highly acceptable score: Panelist score x 7

Moderately acceptable score: Panelist score x 5

Unacceptable score: Panelist score x 2

Considering the sweetness, sourness, crispiness and fibre of amaranth consumers prefer the cultivar Bashpata. The cultivar Bashpata got the top score (2828) based on total acceptability ranking (Table 9) and second score (2548) obtained by BARI danta 1 while the lowest score recorded in Katua (1652).

Consumers prefer light green color and did not prefer the pale red skinned color. However, the preference of appearances was possibly influenced by the brightness of color and number of branches. Light green skinned and maximum branches were highly preferred. Katua obtained maximum branches (18.4) and light green skin color but failed to get top score for its high fibrousness. BARI danta 1 obtained no branch and pale red skinned color, for that it got second score (2548).

In case of color preference of amaranths, very few literatures were available so far in my knowledge.

Again, the cultivars that topped the list of total acceptability score necessarily did not obtain the highest score in appearance of fresh amaranth and in fibrousness, sweetness, sourness and crispiness of cooked amaranth. In this observation Bashpata obtained topped acceptability score in all cases.

Based on this survey, superior selection of cultivar should be caring for to choice the entries to be grown through sensory evaluation. Among these three cultivars Bashpata was superior to others.

The present findings give an indication of the consumers' likings of different characters of amaranth.

CHAPTER 5

SUMMARY

A study was conducted to evaluate the performance of three cultivars of amaranth at five different levels of N application in respect of yield and yield contributing characters and organoleptic (taste and visual acceptability) test at the Horticultural Farm and Laboratories of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka–1207, during March to June, 2005. Morphological characters like stem color, leaf color, base color, vein color, pubescence and petiole color were recorded. Yield and yield contributing characters like plant height (cm), number of leaves, length of leaves, breadth of leaves, petiole length, number of branches and stem girth at 25 DAS, 40 DAS and 55 DAS were noted and per plant weight of leaves and stem, leaf stem ratio were also recorded. Thus weight per plant (g), total weight (kg) per unit plot, yield (t/ha) at final harvest(55 DAS) were calculated, dry matter estimation and organoleptic test were studied at 55 DAS by applying 0, 87, 92, 97 and 102 kg N/ha.

The maximum plant height (109.7 cm), leaf length (20.1 cm), fresh weight of stem per plant (471.4g), leaf-stem ratio (1:1.89), fresh weight per plant (721.0 g) and yield per plot (10.8 kg) were obtained from Bashpata by applying 97 kg N/ha at final observation 55 DAS.

The maximum leaf breadth (11.6 cm) and the minimum % dry matter (11.49) were recorded from BARI danta 1 by applying N 102 kg/ha.

The maximum number of branches per plant (24.3), number of leaves per plant (370.8), fresh weight of leaves per plant (274.7g), dry weight per plant (109.9 g) were recorded from Katua at the highest level of N 102 kg/ha at 55 DAS and maximum % dry matter was from Katua (19.13) at control treatment.

The maximum yield per hectar (72.1 t/ha) was obtained from Bashpata at 97 kg N/ha which was closely followed by Katua (65.6 t/ha) and BARI danta 1 (34.0 t/ha) at the highest N level 102 kg/ha.

Considering the sweetness, sourness, crispiness and fibre of amaranth consumers prefer the cultivar Bashpata. The cultivar Bashpata got the top score (2828) based on total acceptability ranking and second score (2548) obtained by BARI danta 1 while the lowest score recorded in Katua (1652). Among these three cultivars Bashpata was superior to others. However, these three cultivars are commercially popular in different regions of the country.

CONCLUSION AND RECOMMENDATION

Present study generated information on productivity of three commercial amaranth cultivars at five levels of nitrogen which may help selection of cultivars, and nitrogen level for successful commercial production. These as follows:

The optimum level of nitrogen fertilizer application was found to be 97 kg N/ha for Bashpata in presence of recommended doses of P_2O_5 48 kg, K_2O 120 kg/ha and cowdung 20 t/ha. Yield increased with increasing N level BARI danta 1 and Katua showed best performance at the highest N level 102 kg N/ha. Therefore further investigation is suggested with higher doses of N/ha. Among the three cultivars Bashpata was superior to in over all consideration.

As such, long term research program should be initiated to generate useful detail information about optimum level of fertilizers application and superior selection of amaranth cultivar with quality. However, further investigation is suggested to confirm the result of this study since the cultivars were grown in one year only and incorporating desirable traits to improve.

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Appendix I. Characters of Horticultural farm soil as analyzed by Soil Resources Development Institute (SRDI), Khamar Bari, Farmgate, Dhaka.

Morphological characters of the experimental field

Morphological features	Characters
Location	Horticulture Garden,SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soils
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Lettuce - Amaranth

Appendix II. Monthly records of temperature, relative humidity, rainfall, soil temperature, sunshine of the experimental site during the period from February to July, 2005

Year	Month	Air temperature (^{0} C)			Relative Humidity (%)	Rainfall (mm)	Soil temperature (^{0} C)			Sunshine (hrs)
		Max	Min	Ave			5 cm depth	10 cm depth	20 cm depth	
2005	February	28.88	17.98	23.43	61.04	03	12.9	12.9	13.8	221.5
	March	32.22	21.78	27.00	66.69	155	16.2	16.2	17.2	210.2
	April	30.01	21.79	25.10	82.00	245.5	28.0	28.4	28.0	177.0
	May	33.01	25.39	29.20	81.58	146.0	30.8	31.2	30.6	222.9
	June	31.18	25.51	28.34	88.23	332.7	30.5	30.8	30.4	101.0
	July	30.74	25.88	28.31	87.00	787.2	30.4	30.6	30.3	119.9

Appendix III. Questionnaire on taste and visual acceptability of amaranth

	Characters														
Sample	Color			Taste and smell									Fibre		
	HA	MA	UA	Sweetness			Sourness			Crispiness			HA	MA	UA
				HA	MA	UA	HA	MA	UA	HA	MA	UA			
BARI danta-1															
Bashpata															
Katua															

* Please give (√) mark against the desire treatment with desire component

** Note:

HA = Highly Acceptable

MA = Moderately Acceptable

UA = Unacceptable

Name and Signature of judge: ....and..................................

Address: ....Age..........Profession...............................

Date: ....

Appendix IV. Summarized data of organoleptic test from 100 panelists

Parameters	Cultivars								
	BARI danta 1			Bashpata			Katua		
	HA	MA	UA	HA	MA	UA	HA	MA	UA
Color	60	32	8	84	12	4	64	32	4
Sweetness	60	36	4	64	28	8	48	44	8
Sourness	92	8	0	92	4	4	64	24	12
Crispiness	80	12	8	84	12	4	40	40	20
Fibre	72	24	4	80	12	8	20	36	44
Total	364	112	24	404	68	28	236	176	88