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Effects of Variety Spacing and Nitrogen on Growth and Yield of Stem Amaranth

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Abstract:

An experiment was conducted at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh during the period from 19 March, 2013 to 10 May, 2013 to study the effects of variety, spacing and nitrogen on growth and yield of stem amaranth. The experiment consisted of two varieties viz; Data Bhutan, and Red Force

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and three levels of nitrogen viz; control, 175 kg/ha, 200 kg/ha and three plant spacing viz; 25 cm x 10cm, 25 cm x 15 cm, 25 cm x 20 cm. The experiment was laid out in the randomized complete block design (RCBD) with three replications. The highest yield (26.89 t/ha) that was found from the variety Data Bhutan. Considering the combined effect of variety and nitrogen the highest yield (32.22 t/ha) was found from Data Bhutan and 175 kg N/ha. The highest yield was found (32.22 t/ha) from the variety Data Bhutan with the application of 175 kg N/ha. The highest yield (30.74 t/ha) was obtain from the closest spacing (25 cm x 10 cm). The highest yield of stem amaranth obtain (30.74 t/ha) was found from the variety Data Bhutan planted at the closest spacing (25 cm x10 cm). The highest yield (36.00 t/ha) was found from the combination of the variety Data Bhutan, spacing (25 cm x l5 cm) and application 175 kg N/ha.

Key words: Variety, spacing, nitrogen dose, growth, yield and stem amaranth.

INTRODUCTION

Stem amaranth (*Amaranthus lividus*) is one of the most important vegetables grown throughout the tropical world including Bangladesh. Stem amaranth belongs to the genus *Amaranthus*, family Amaranthaceae, native to the India or Indo-Chinese region. The tender leaves and stems, rich in vitamins A, vitamin C, calcium and iron, are considered as vegetables (Kigel, 1994). Two predominant types are grown; the leafy type can be cultivated throughout the year but its production is high during winter months. The stem type is a vegetable primarily of the summer season (Becerra, 2000). Amaranths (*Amaranth spp.)* grown for vegetable vary throughout the world and they bear numerous names as African Spinach, tampala in China and pigweed in India (Cole, 1979). Grubben (1977) reported a variety of Asian amaranths grown in Nigeria and West Indies. Amaranthus plays an

important role in nutrition among the leafy vegetables grown in Bangladesh. Among the vegetables of tropics, Amaranths are very easy to grow. Amaranth is probably the most populous vegetables due to its short length, quick growing habit and riches in vitamins and minerals. The leafy amaranth is said to be the native of India (Shanmugavelu, 1989; Nath, 1976). Among the leafy types *Amaranthus tricolor* L. is the most commonly cultivated species in Bangladesh. It is cultivated all over the country in any season due to its adaptability to wide range of soil and climate. However, during winter its growth and development is slower than summer and rainy season (Islam and Hossain, 1992).

Growth, yield and quality of amaranth depend on nutrient availability in soil which is related to the judicious application of manures and fertilizers. Nutrients may be applied through two sources viz. organic and inorganic sources. Like other leafy vegetables, in amaranth cultivation application of nitrogen is very essential. It is necessary for its growth and development, particularly for growth of leaf and healthy shoot development. Nitrogen is required for quick vegetative growth and increased yield.

The importance of spacing in amaranths is attributed to higher yield. Available evidences reveal that in stem amaranth production, both spacing and nitrogen fertilizer play an important role. The yield of stem amaranth may be increased through appropriate combination of plant spacing and nitrogen fertilizer application. The experimental evidences on the effect of plant spacing and nitrogen application on the growth and yield components of stem amaranth varieties are limited under Bangladesh conditions. The objective of the present experiment is to investigate the effects of variety, spacing and different doses of nitrogen on growth and yield of stem amaranth.

METHODS AND MATERIALS

The present study was carried out at the Horticulture Farm, Bangladesh Agricultural University, Mymensingh during the period from March to May, 2013. The area is located at 24^0 46' latitude and90^o 24' longitude. The climate of the experimental area was sub-tropical in nature characterized by high temperature, heavy rainfall, high humidity and relatively long day during the month of March to August and scanty rainfall associated with moderately low temperature, low humidity and short day during the rest period of the year. The experimental plot was a high land belonging to the Old Brahmaputra Flood plain Alluvial Tract of Agro ecological zone 9 (AEZ-30). The soil texture was silty loam with pH 6.6.

This experiment consisted of following factors:

Factor A (Variety)	Factor B (Nitrogen)	Factor C(Spacing)
Data Bhutan	N_0= 0 kg/ha	S_1 = 25 cm x10 cm
Red Force	N_1= 175 kg/ha	S_2 = 25 cm x15 cm
	N_2= 200kg/ha	S_3 = 25 cm x 20 cm

The experiment was laid out in the Randomized complete Brock Design (RCBD) with 3 replications. The treatment combinations were randomly assigned to each unit plot so as to allot one treatment combination once in each replication. A unit plot was 1.2 m x 1.0 m in size. The experiment was laid out in the Randomized complete Brock Design (RCBD) with 3 replications. The treatment combinations were randomly assigned to each unit plot so as to allot one treatment combination once in each replication. The following doses of manure and fertilizers were applied in the experimental plot as per recommendation of BARC (2005):

Nutrients	Dose
N	Nitrogen was applied as per treatment
P	80 kg P/ha
K	50 kg K/ha
Cowdung	1.5 t/ha

Urea, TSP and MOP were the sources of Nitrogen, P and K respectively.

Full doses of cowdung, P, and K were applied during final land preparation and N applied at different days after sowing (DAS). Harvesting was done on 10 May, 2013 when plants become mature. The following parameters were considered for data collection. Such as Seedling emergence, Plant height, Total number of leaves per plant, Stem diameter, Leaf area, Yield per plot and Yield per hectare. The collected data on various parameters were statistically analyzed using MSTAT-C package program. The mean for all the treatments were calculated and analyzed and analyses of variance of all the characters were performed by F-variance test. The significance of differences between the pairs of treatment means was calculated by the least significant difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

RESULTS

Effects of variety on the growth and yield of stem amaranth

All the growth and yield of stem amaranth showed significant variations at 1% level of probability (Table 1). The highest emergence of seedling at 4 and 6 DAS were 53.83 and 73.14 recorded from the variety Data Bhutan and Red Force and the lowest were 33.55 and 71.89 in Red Force. Plant height is one of the most important growth parameter for growth of plant. At 50 DAS, the highest plant height was recorded in the variety Data Bhutan and the lowest plant height was recorded in the variety Red Force. At 15 and 50 DAS, the highest number of leaves per

plant 5.62 and 22.80 was recorded from the variety Data Bhutan and the lowest number of leaves per plant 5.24 and 20.97 was recorded from the variety Red Force. At 23 and 50 DAS, the highest stem diameter 0.496 cm and 1.50 cm were recorded from the variety Data Bhutan and lowest stem diameter 0.449 cm and 1.44 cm was recorded from the variety Red Force. The highest leaf area (1164.19 cm^2) was recorded from the variety Data Bhutan and the lowest leaf area (994.80 cm2) was recorded the variety Red Force. The highest yield (26.89 t/ha) was observed at Data Bhutan and lowest yield (22.06) was observed from Red Force.

Table 1: Effects of variety on the growth and yield of stem amaranth

Variety	(%) of seedling Emergence		Plant height (cm) at					Number of leaves per plant					Stem diameter (cm)				Leaf area/plant (cm^2)	Yield t/ha
	4 DAS	**6 DAS**	**15 DAS**	**23 DAS**	**29 DAS**	**37 DAS**	**50 DAS**	**15 DAS**	**23 DAS**	**29 DAS**	**37 DAS**	**50 DAS**	**23 DAS**	**29 DAS**	**37 DAS**	**50 DAS**		
Data Bhutan	53.83	71.89	5.15	9.81	19.34	42.13	64.23	5.62	8.23	15.82	18.01	22.80	0.496	0.619	0.764	1.50	1164.19	26.89
Red Force	33.55	73.14	4.72	9.18	17.09	40.10	59.13	5.24	7.90	14.09	16.82	20.97	0.449	0.581	0.727	1.44	994.80	22.06
LSD at 5%	0.238	0.367	0.058	0.049	0.092	0.141	0.170	0.049	0.052	0.058	0.096	0.108	0.006	0.006	0.006	0.006	9.989	0.265
LSD at 1%	0.320	0.493	0.078	0.066	0.124	0.189	0.229	0.066	0.070	0.078	0.129	0.145	0.007	0.007	0.007	0.007	13.439	0.357
Level of significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

** Significant at 1% level of probability

Effects of nitrogen on the growth and yield of stem amaranth

All the growth and yield of stem amaranth showed significant variations at 1% level of probability (Table 1). The effects of different levels of nitrogen on plant height of stem amaranth at different days after sowing have been presented in Fig 1. There was increasing trend of plant height observed from 15 DAS to 50 DAS. At 15 DAS, the highest number of leaves per plant (6.06) was produced by plants when applied with 175 kg N/ha and the lowest number of leaves per plant (4.61) at no nitrogen application. At 23 DAS, the highest number of leaves per plant (8.45) was produced at 175 kg N/ha and the lowest number of leaves per plant (7.71) was recorded no nitrogen application. The higher number of leaves per plant (23.07) was recorded at 50 DAS with 175 kg N/ha and the lowest number of leaves per

plant (19.83) was recorded at no nitrogen application. At 23 DAS, the highest stem diameter (0.494 cm) was recorded at 175 kg N/ha and the lowest stem diameter (0.447 cm) was recorded at no nitrogen application. At 37 DAS, the highest stem diameter (0.820 cm) was recorded at 175 kg N/ha and the lowest stem diameter (0.630 cm) was recorded at no nitrogen application. At 50 DAS, the highest stem diameter (1.61 cm) was found at 175 kg N/ha and the lowest stem diameter (1.25 cm) was found at control level of nitrogen. The highest leaf area (1315.81 $cm^{2)}$ was found at 175 kg N/ha and the lowest leave area (700.22 cm^2) was found at 0 kg N/ha. The highest yield per hectare (29.34 ton/ha) was found at 175 kg N/ha and the lowest yield per hectare (17.04 kg/ha) was found from no nitrogen application.

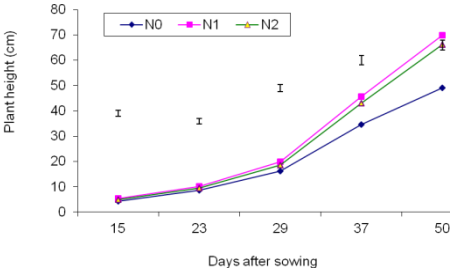

Fig. 1: Main Effect of different levels of nitrogen on plant height of stem amaranth (The vertical bars represent LSD at 5% level of significance)

Table 2: Main effect of nitrogen on the growth and yield of stem amaranth

Nitrogen	(%) Emergence at		Number of leaves per plant					Stem diameter (cm) at				Leaf area/plant (cm^2)	Yield t/ha
	4 DAS	**6 DAS**	**15 DAS**	**23 DAS**	**29 DAS**	**37 DAS**	**50 DAS**	**23 DAS**	**29 DAS**	**37 DAS**	**50 DAS**		
0 kg N/ha	40.52	62.66	4.61	7.71	13.94	16.87	19.83	0.447	0.535	0.630	1.25	700.22	17.04
175 kg N/ha	44.22	77.39	6.06	8.45	15.77	17.95	23.07	0.494	0.647	0.820	1.61	1315.81	29.34
200 kg N /ha	46.33	77.50	5.63	8.03	15.15	17.42	22.73	0.477	0.618	0.787	1.55	1222.45	27.05
LSD at 5%	0.078	0.097	0.036	0.037	0.039	0.050	0.053	0.012	0.012	0.012	0.012	0.508	0.083
LSD at 1%	0.105	0.130	0.048	0.049	0.052	0.067	0.071	0.016	0.016	0.016	0.016	0.680	0.111
Level of significance	**	**	**	**	**	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability

Effects of spacing on the growth and yield of stem amaranth

All the growth and yield of stem amaranth showed significant variations at 1% level of probability (Table 3).The main effect of spacing on plant height of stem amaranth at different days after sowing have been presented in Fig. 2. At 15,23,29,37 DAS, the highest plant height was found from spacing at (25 cm x 15 cm) and the lowest plant height was found from spacing at (25 cm x20 cm). At 50 DAS, the highest plant height (63.94 cm) was found from the plant spacing (25 cm x15 cm) and the lowest plant height (59.27 cm) was found from the (25 cm x 20 cm) wider plant spacing. At 23, 29, 37 DAS, the highest stem diameter were recorded from the spacing 25 cm x 15 cm and the lowest stem diameter from the spacing 25 cm x 20 cm. The highest stem diameter (1.52 cm) was found from the medium plant spacing (25 cm x 15 cm) and the lowest stem diameter (1.42 cm) was found from the closest spacing (25 cm x 10 cm) at 50 DAS. The highest leaf area (1269.76 cm^2) was found from the spacing (25 cm x 15 cm) and the lowest leaf area (935.44 cm^2) was found from the spacing (25 cm x 10 cm). The maximum leaf area was recorded in the medium spacing and the possible reason could be that plant did not compete for nutrients, light, and other environmental factors. The highest yield (30.74 t/ha) was found from closest spacing (25 cm x 10 cm) and the lowest yield (18.75 t/ha) was found from wider spacing (25 cm x 20 cm).The highest yield in closest plant spacing possible reason could be that accommodation of more number of plants.

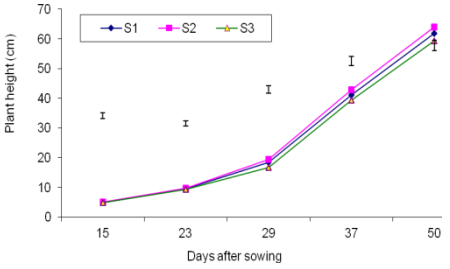

Fig. 2: Main effect of plant spacing on plant height of stem amaranth (The vertical Bars represent LSD at 5% level of significance)

Table 3: Effects of spacing on the growth and yield of stem amaranth

Spacing	Number of leaves per plant at					Stem diameter (cm) at				Leaf area/plant (cm^2)	Yield t/ha
	15 DAS	**23 DAS**	**29 DAS**	**37 DAS**	**50 DAS**	**23 DAS**	**29 DAS**	**37 DAS**	**50 DAS**		
25 cm x 10 cm	5.62	8.06	15.11	17.39	21.80	0.468	0.605	0.743	1.46	1033.97	30.74
25 cm x 15 cm	5.74	8.23	15.53	18.25	22.93	0.491	0.642	0.775	1.52	1269.06	22.34
25 cm x 20 cm	4.94	7.91	14.22	16.59	20.91	0.458	0.553	0.718	1.42	935.44	18.75
LSD at 5%	0.036	0.037	0.039	0.050	0.053	0.012	0.012	0.012	0.012	0.508	0.083
LSD at 1%	0.048	0.049	0.052	0.067	0.071	0.016	0.016	0.016	0.016	0.680	0.111
Level of significance	**	**	**	**	**	**	**	**	**	**	**

** Significant at 1% level of probability

Combined Effects of variety and nitrogen on the growth and yield of stem amaranth

All the growth and yield of stem amaranth showed significant variations at 1% level of probability (Table 4). At 15, 23, 29, 37 DAS, the highest plant height was recorded from the treatment combination of variety Data Bhutan with the application of 175 kg N/ha and the lowest plant height was recorded from the treatment combination of variety Red Force and at 0 kg N/ha. At 50 DAS, the highest plant height (72.71 cm) was recorded from the treatment combination of Data Bhutan with the application of 175 kg N/ha and the lowest plant height (53.37 cm) was recorded where no nitrogen was applied with same variety. At 15 DAS, the highest number of leaves per plant (6.47) was found from the treatment combination of variety Data Bhutan and at 175 kg N/ha and the lowest number of

leaves per plant (5.54) was found from the treatment combination of variety Data Bhutan and at 0 kg N/ha. At 50 DAS, the highest number of leaves per plant (24.09) was found in the treatment combination of variety Data Bhutan and at 175 kg N/ha and the lowest number of leaves per plant (19.28) was found from the treatment combination of variety Data Bhutan and no nitrogen application. At 50 DAS, the highest stem diameter (1.65 cm) was recorded from the treatment combination of variety Data Bhutan and at 175 kg N/ha and lowest stem diameter (1.23 cm) was recorded from the treatment combination of variety Red Force and no nitrogen application. The highest leaf area (1420.03 cm^2) found from the treatment combination of variety Data Bhutan and at 175 kg N/ha and the lowest leaf area (618.32 cm^2) was found from variety Red Force and no nitrogen application. The combined effects of variety and nitrogen on yield per hectare have been presented in Fig. 3. The higher yield (32.22 t/ha) was found from the treatment combination of the variety Data Bhutan and at 175 kg N/ha and the lowest yield (14.63 t/ha) was found from the treatment combination of the variety Red Force with no nitrogen application.

Table 4: Combined Effects of variety and nitrogen on the growth and yield of stem amaranth

Variety x Nitrogen	Plant height (cm) at					Number of leaves per plant at					Stem diameter (cm) at				Leaf area/plant (cm^2)
	15 DAS	**23 DAS**	**29 DAS**	**37 DAS**	**50 DAS**	**15 DAS**	**23 DAS**	**29 DAS**	**37 DAS**	**50 DAS**	**23 DAS**	**29 DAS**	**37 DAS**	**50 DAS**	
Data Bhutan x 0 kg N/ha	4.66	8.93	16.69	35.55	53.37	4.68	7.84	14.99	17.41	20.39	0.473	0.570	0.643	1.26	782.12
Data Bhutan x 175 kg N/ha	5.49	10.55	21.55	46.43	72.71	6.47	8.59	16.59	18.54	24.09	0.518	0.657	0.837	1.65	1420.03
Data Bhutan x 200 kg N/ha	5.30	9.96	19.78	44.42	66.60	5.72	8.26	15.87	18.07	23.92	0.497	0.630	0.813	1.58	1290.42
Red Force x 0 kg N/ha	4.10	8.41	15.58	33.53	44.64	4.54	7.59	12.89	16.33	19.28	0.420	0.500	0.617	1.23	618.32
Red Force x 175 kg N/ha	5.23	9.87	18.40	45.06	67.19	5.66	8.31	14.95	17.36	22.06	0.470	0.637	0.803	1.57	1211.59
Red Force x 200 kg N/ha	4.82	9.26	17.28	41.71	65.57	5.54	7.81	14.44	16.77	21.55	0.457	0.607	0.760	1.53	1154.49
LSD at 5%	0.055	0.050	0.069	0.085	0.094	0.050	0.052	0.055	0.070	0.075	0.017	0.017	0.017	0.017	0.718
LSD at 1%	0.073	0.068	0.093	0.114	0.126	0.068	0.070	0.073	0.094	0.100	0.023	0.023	0.023	0.023	0.962
Level of significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

** Significant at 1% level of probability

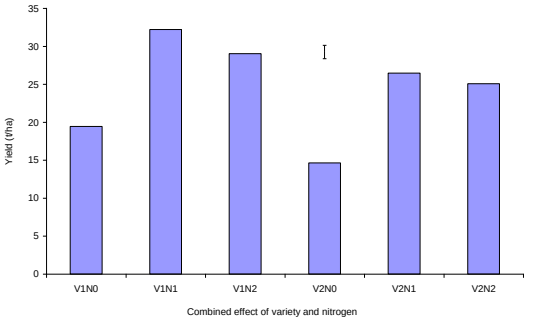

Fig. 3: Combined effect of variety and nitrogen on yield of stem amaranth (The vertical bar represents LSD at 5% level of probability)

Combined Effects of variety and spacing on growth and yield of stem amaranth

The combined effects of variety and plant spacing at different days after planting was found statistically significant at 15 DAS, 29 DAS, 37 DAS and 50 DAS (Table 5). At 15, 23, 29, 37 DAS, the highest plant height was found from treatment combination of variety Data Bhutan and spacing (25 cm x 15 cm) and the lowest plant height was found from treatment combination of variety Red Force and spacing (20 cm x 25 cm). At 50 DAS, the highest plant height (66.91 cm) was found from treatment combination of variety Data Bhutan and spacing (25 cm x 15 cm) and the lowest plant height (57.24 cm) was found from treatment combination of the Red Force and wider spacing (25 cm x 20 cm). At 15 DAS, the highest number of leaves (5.90) per plant was found from the combination of the variety Data Bhutan and spacing (25 cm x 15 cm) and lowest number of leaves (4.77) per plant was found from the combination of the variety Red Force and spacing (25 cm x 20 cm). The combined effects of varieties and different plant spacing had significant effects at 29 and 37 DAS. At 29 DAS, the highest stem diameter (0.653 cm) was found from the combination of variety Data Bhutan and spacing (25 cm x 10 cm) and the lowest stem diameter (0.527 cm) was found from the combination of variety Red Force and the closest plant spacing (25 cm x 10 cm). The

highest stem diameter (0.80 cm) was found from the combination of variety Data Bhutan and spacing (25 cm x 15 cm) and lowest stem diameter (0.71 cm) was found from the combination of variety Red Force and plant spacing (25 cm x 20 cm) at 37 DAS. The combined effect of different plant spacing and varieties on leaf area of the plant was found significant. The highest plant leaf area (1363.15 cm^2) was found from the combination of variety Data Bhutan and spacing (25 cm x 15 cm) and the lowest leaf area (871.84 $cm^{2)}$ was found from the combination of variety Red Force and spacing (25 cm x 20 cm). The combined effects of variety and spacing on yield per hectare have been presented in (Fig.4). The combined effects of variety and spacing had significant effect on yield per hectare. The higher yield (35.30 t/ha) was found from the combination of the variety Data Bhutan and closest spacing (25 cm x l0 cm) and the lowest yield (17.39 t/ha) was found from the combination of the variety Red Force and wider spacing (25 cm x 20 cm).

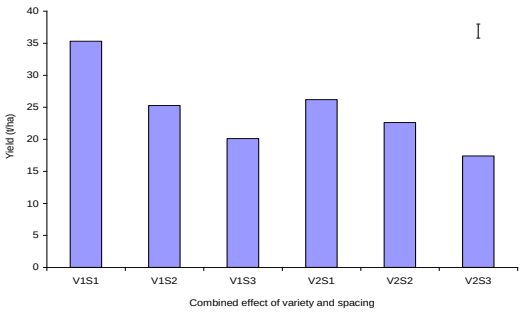

Fig.4: Combined effect of variety and spacing on yield of stem amaranth (The vertical bar represents LSD at 5% level of probability)

Table 5: Combined Effects of variety and spacing on growth and yield of stem amaranth

Variety x Spacing	Plant height (cm) at					Number of leaves per plant at					Stem diameter (cm) at				Leaf area/plant (cm^2)
	15 DAS	**23 DAS**	**29 DAS**	**37 DAS**	**50 DAS**	**15 DAS**	**23 DAS**	**29 DAS**	**37 DAS**	**50 DAS**	**23 DAS**	**29 DAS**	**37 DAS**	**50 DAS**	
Data Bhutan x (25 cm x 10cm)	5.21	9.82	19.52	42.24	64.47	5.86	8.19	15.92	17.92	22.84	0.493	0.623	0.767	1.50	1130.36
Data Bhutan x (25 cm x 15 cm)	5.33	9.97	20.71	43.57	66.91	5.90	8.39	16.25	19.11	23.74	0.514	0.653	0.800	1.55	1363.15
Data Bhutan x (25 cm x 20 cm)	4.91	9.65	17.78	40.59	61.30	5.11	8.10	15.28	17.00	21.81	0.480	0.580	0.727	1.45	999.05
Red Force x (25 cm x 10 cm)	4.68	9.19	17.45	40.00	59.19	5.39	7.92	14.30	16.86	20.76	0.443	0.587	0.720	1.43	937.58
Red Force x (25 cm x 15 cm)	4.82	9.35	18.11	42.19	60.97	5.57	8.06	14.80	17.40	22.12	0.467	0.630	0.750	1.50	1174.98
Red Force x (25 cm x 20 cm)	4.66	9.00	15.71	38.12	57.24	4.77	7.72	13.17	16.19	20.02	0.437	0.527	0.710	1.40	871.84
LSD at 5%	0.101	0.086	0.160	0.244	0.295	0.086	0.091	0.101	0.166	0.187	0.010	0.010	0.010	0.010	17.342
LSD at 1%	0.135	0.115	0.215	0.328	0.396	0.115	0.122	0.135	0.223	0.250	0.013	0.013	0.013	0.013	23.254
Level of significance	**	**	**	**	**	*	NS	**	**	**	**	**	**	**	**

** Significant at 1% level of probability NS = Non significance

Combined effects of variety, spacing and nitrogen on the growth and yield of stem amaranth

All the growth and yield of stem amaranth showed significant variations at 1% and 5% level of probability (Table 6). At 4 DAS, the highest emergence of seedling (58.33) was obtained from the combined effects of 200 kg N/ha, variety Data Bhutan and spacing (25 cm x 10 cm) and the lowest emergence of seedling (28.33). At 6 DAS, the highest emergence of seedling (80.00) was obtained from treatment combination of variety Data Bhutan, spacing (25 cm x 20 cm) and 200 kg N/ha application and the lowest emergence of seedling (61.67) was from treatment combination of variety Data Bhutan, same spacing and at 0 kg N/ha. At 15,23,29,37 DAS, the highest plant height was recorded from the treatment combination of variety Data Bhutan and spacing (25 cm x 15 cm) with the

application of 175 kg N/ha and the lowest plant height were recorded from the treatment combination of variety Red Force, spacing (25 cm x10 cm) and at 0 kg N/ha. At 50 DAS, the highest plant height (74.77 cm) was found from the treatment combination of variety Data Bhutan, spacing (25 cm x 15 cm) and at 175 kg N/ha and the lowest plant height (42.94 cm) was recorded from the treatment combination of variety, Red Force spacing (25 cm x10 cm) and no nitrogen application. At 15,23,29,37 DAS, the highest number of leaves per plant was found from the treatment combination of variety Data Bhutan, spacing (25 cm x 15 cm) and at 175 kg N/ha and the lowest number of leaves per plant was found from the treatment combination of variety Red Force, spacing (25 cm x 10 cm) and at 0 kg N/ha. At 50 DAS, the highest number of leaves per plant (24.83) was recorded from the treatment combination of variety Data Bhutan, spacing (25 cm x 10 cm) and at 175 kg N/ha and the lowest number of leaves per plant (17.81) was recorded from the treatment combination of variety Red Force, spacing (25 cm x 10 cm) and no nitrogen application. At 29 DAS, the highest stem diameter (0.690 cm) was recorded from the treatment combination of variety Data Bhutan spacing (25 cm x 15 cm) and at 175 kg N/ha and lowest stem diameter (0.520 cm) was recorded from the treatment combination of variety Red Force, spacing (25 cm x 10 cm) and no nitrogen application. The highest plant leaf area (1783.99 cm^2) was found from the combination of variety Data Bhutan, 175 kg/ha and spacing (25 cm x 15 cm) and the lowest leaf area (527.36 $cm^{2)}$ was found from the combination of variety Red Force, spacing (25 cm x 20 cm) and no nitrogen application, Variety, nitrogen and spacing had significant combined effects on yield per hectare of stem amaranth. The highest yield (36.00 t/ha) was found from the combination of the variety Data Bhutan, 175 kg/ha and spacing (25 cm x l5 cm) and the lowest yield (10.83 t/ha) was found from

the combination of the variety Red Force, wider spacing (25 cm x 20 cm) and no application of nitrogen.

Table 6: Combined effects of variety, spacing and nitrogen on seedling emergence, plant height, number of leaves per plant, stem diameter, leaf area, and yield per hectare of stem amaranth

Variety x Nitrogen level x spacing	Plant height (cm) at					No. of leaves/plant at				
	15 DAS	23 DAS	29 DAS	37 DAS	50 DAS	15 DAS	23 DAS	29 DAS	37 DAS	50 DAS
$V_1N_0S_1$	4.91	8.94	16.91	34.94	54.05	4.90	7.83	15.65	17.33	20.90
$V_1N_0S_2$	4.69	8.98	16.98	37.19	57.25	4.96	7.89	15.17	18.08	21.67
$V_1N_0S_3$	4.40	8.89	16.18	34.54	48.81	4.19	7.80	14.17	16.83	18.60
$V_1N_1S_1$	5.38	10.58	22.31	46.54	72.57	6.81	8.63	16.13	18.56	23.97
$V_1N_1S_2$	5.73	10.92	23.14	47.57	74.77	6.83	8.72	17.52	19.83	24.83
$V_1N_1S_3$	5.37	10.15	19.21	45.20	70.80	5.79	8.44	16.13	17.25	23.47
$V_1N_2S_1$	5.36	9.96	19.36	45.26	66.80	5.87	8.13	15.98	17.89	23.67
$V_1N_2S_2$	5.59	10.02	22.01	45.96	68.72	5.93	8.58	16.08	19.42	24.73
$V_1N_2S_3$	4.96	9.91	17.97	42.04	64.30	5.36	8.08	15.55	16.92	23.36
$V_2N_0S_1$	4.03	8.41	15.83	32.71	45.14	4.65	7.63	13.42	16.42	18.58
$V_2N_0S_2$	4.27	8.58	16.08	35.71	45.86	4.86	7.70	13.48	17.00	21.47
$V_2N_0S_3$	4.00	8.24	14.85	32.19	42.94	4.11	7.44	11.77	15.58	17.81
$V_2N_1S_1$	5.21	9.98	18.65	45.06	66.99	5.80	8.40	15.08	17.25	22.12
$V_2N_1S_2$	5.30	10.05	19.28	45.73	69.50	6.04	8.46	15.85	18.00	22.58
$V_2N_1S_3$	5.19	9.59	17.28	44.39	65.10	5.14	8.07	13.92	16.83	21.50
$V_2N_2S_1$	4.80	9.20	17.87	42.23	65.46	5.72	7.74	14.42	16.92	21.59
$V_2N_2S_2$	4.89	9.42	18.97	45.13	67.56	5.83	8.03	15.08	17.22	22.33
$V_2N_2S_3$	4.79	9.18	15.00	37.78	63.69	5.07	7.67	13.83	16.17	20.75
$LSD_{0.05}$	0.35	0.33	0.45	0.55	0.60	0.33	0.34	0.35	0.45	0.48
$LSD_{0.01}$	0.47	0.44	0.59	0.74	0.81	0.43	0.45	0.47	0.61	0.64
Level of significance	**	**	**	**	**	*	**	**	**	**

Variety x Nitrogen level x spacing	Stem diameter at				% Seedling emergence at		Leaf area	Yield/plot (kg)	Yield (t/ha)
	23 DAS	29 DAS	37 DAS	50 DAS	4 DAS	6 DAS			
$V_1N_0S_1$	0.48	0.58	0.65	1.27	51.29	61.67	755.06	3.39	28.25
$V_1N_0S_2$	0.48	0.57	0.66	1.31	51.00	60.00	853.16	2.05	17.08
$V_1N_0S_3$	0.46	0.56	0.62	1.22	50.20	61.00	738.14	1.56	13.00
$V_1N_1S_1$	0.50	0.67	0.84	1.66	54.67	73.67	1342.18	4.81	36.08
$V_1N_1S_2$	0.55	0.70	0.88	1.71	55.67	76.67	1783.99	3.60	30.00
$V_1N_1S_3$	0.50	0.60	0.79	1.59	55.00	85.67	1133.92	3.19	26.58
$V_1N_2S_1$	0.50	0.62	0.81	1.57	53.33	73.33	1293.85	4.51	27.58
$V_1N_2S_2$	0.51	0.69	0.86	1.63	55.00	75.00	1452.32	3.45	28.75
$V_1N_2S_3$	0.48	0.58	0.77	1.54	58.33	80.00	1125.10	2.49	20.75
$V_2N_0S_1$	0.41	0.52	0.62	1.25	32.33	63.33	596.26	2.10	17.50
$V_2N_0S_2$	0.45	0.55	0.62	1.26	28.33	66.67	731.35	1.87	15.58
$V_2N_0S_3$	0.40	0.43	0.61	1.20	30.00	63.33	527.36	1.30	10.83
$V_2N_1S_1$	0.47	0.64	0.79	1.54	30.00	73.33	1115.45	4.11	34.25
$V_2N_1S_2$	0.48	0.68	0.85	1.65	36.67	78.33	1420.45	3.09	25.75
$V_2N_1S_3$	0.46	0.59	0.77	1.52	33.33	76.67	1098.88	2.33	19.42
$V_2N_2S_1$	0.45	0.60	0.75	1.50	34.68	83.33	1101.05	3.22	26.83
$V_2N_2S_2$	0.47	0.66	0.78	1.60	36.67	71.67	1373.14	3.18	26.50
$V_2N_2S_3$	0.45	0.56	0.75	1.49	40.00	81.67	989.28	2.63	21.91
$LSD_{0.05}$	0.11	0.11	0.11	0.11	0.72	0.89	4.64	0.27	0.75
$LSD_{0.01}$	0.15	0.14	0.15	0.14	0.96	1.19	6.22	0.32	1.01
Level of significance	**	**	**	**	**	**	**	**	**

** Significance at 1% level of probability * Significance at 5% level of probability
NS = Non Significance DAS = Days after sowing
V1 = Data Bhutan V2 = Red Force N0 = 0 kg/ha S1 = 25 cm X 10 cm
N1 = 175 kg/ha S2 =25 cm X 15 cm
N2 = 200 kg/ha S3 =25 cm X 20 c

DISCUSSION

Plant height is one of the important growth contributing characters for stem amaranth. Plant heights recorded from 15 days after sowing to 50 days after sowing. Significant variations were obtained among the stem amaranth varieties under the study at different days after sowing (DAS). At 15, 23, 29, 37, and 50 DAS the highest plant height was recorded in the variety Data Bhutan and the lowest plant height was recorded in the variety Red Force. Different levels of nitrogen on plant height of stem amaranth had significant effect on yield of stem amaranth. Significant variation was observed at 23 DAS, followed by 29 DAS, 37 DAS and 50 DAS. Plant height differed significantly due to the different doses of nitrogen. There was increasing trend of plant height observed from 15 DAS to 50 DAS. At 23 DAS, the highest plant height (10.21 cm) was observed at higher doses of nitrogen and the lowest plant height (8.67 cm) was observed at control level. Similar trend was also found at 29, 37 and 50 DAS of each growth stages of plant and the lowest was observed at control level of nitrogen. The highest level of nitrogen gave highest plant height. The plant height increased with the increase of nitrogen level. The similar results were found by Somchai (2003) and Ready *el al.* (2002). They reported that the plant height increased with the increase of nitrogen levels in amaranth. Omolayo *et al*. (1996) conducted a field experiment on a slightly acid sandy loam soil at the teaching and Research Farm, University of Ado-Ekiti, Nigeria. They studied the effects of different doses of nitrogen on the growth parameters and the yield of leaf amaranth (*Amaranthuscruentus* L). The treatments consisted of 100, 150 and 200 kg N/ha in four replications. Plant height, leaf length, number of leaves stem girth and marketable yield were measured at 5, 6 and 7 weeks after sowing. Plant height, number of leaves and leaf area increased with the application of

poultry manure from the different sources. They found that application of 150 kg of nitrogen per hectare produced the higher number of leaves, plant height and marketable yield. At 29 DAS, the higher stem diameter (0.690 cm) was recorded from the treatment combination of variety Data Bhutan, spacing (25 cm x 15 cm) and at 175 kg N/ha and lowest stem diameter (0.520 cm) was recorded from the treatment combination of variety Red Force, spacing (25 cm x 10 cm) and no nitrogen application. Application of fertilizer had significant effects on leaf area of stem amaranth. The highest leaf area (1315.81 $cm^{2)}$ was found at 175 kg N/ha and the lowest leaf area (700.22 cm^2) was found in 0 kg N/ha. The variation in leaf area among the different levels of nitrogen might be due to the higher dose of nitrogen that encourages the vegetative growth i.e. highest leaf of stem amaranth. It was found that the highest yield (28.66 t/ha) was obtained at 200 kg N/ha at 48 days after sowing (DAS), whereas the lowest yield (17.99 t/ha) in control treatment. The maximum growth and yield of the plant were observed in 25 cm x 20 cm in all the dates of harvests. The highest yield per hectare (29.34 ton/ha) was found at 175 kg N/ha and the lowest yield per hectare (17.04 kg/ha) was found from no nitrogen application. The yield per hectare of stem amaranth showed a gradual increase with the increase of nitrogen levels. Alam (2005) reported that yield increased with the increase of nitrogen level in carrot. The effect of spacing on yield was found highly significant. The highest yield (30.74 t/ha) was found from closest spacing (25 cm x 10 cm) and the lowest yield (18.75 t/ha) was found from wider spacing (25 cm x 20 cm).The highest yield in closest plant spacing possible reason could be that accommodation of more number of plants. Rice *et al.* (1987) studied the effect of different plant spacing (20 x 10 cm, 25 x 15 cm, 30 x 20 cm arid 35 x 25 cm) and nitrogen levels (0, 100, 150, and 200kg/ha) on the growth and yield of amaranth. They found the maximum growth and yield

of amaranth from the treatment combination of (25 x 15 cm) and 200 kg N/ha. The variety, nitrogen and plant spacing had significant effect on yield per hectare of stem amaranth. The highest yield (36.00 t/ha) was found from the combination of the variety Data Bhutan, spacing (25 cm x l5 cm) and application of 175 kg N/ha and the lowest yield (10.83 t/ha) was found from the combination of the variety Red Force, wider spacing (25 cm x 20 cm) and no application of fertilizer. This combination may be recommended for the stem amaranth grower in our country to obtain higher yield.

CONCLUSION

The growth and yield of stem amaranth is not satisfactory in our country due to lack of knowledge about the cultural practices. From the present experiment it is clear that growth and yield of stem amaranth largely depend upon the rate of nitrogen fertilizers, variety and plant spacing. These three factors either singly or in combination influence the growth, quality and yield of the crop. In this experiment the highest yield per hectare (36.00 t/ha) was obtained at the combination of 175 kg N/ha, variety Data Bhutan and 25 cm x 15 cm plant spacing. This experiment was conducted without soil analysis and only two varieties. This combination may be suitable for higher yield of stem amaranth cultivation in other region of the country.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this paper.

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