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EVALUATION OF STEM AMARANTH GENOTYPES FOR GROWING IN WINTER SEASON IN BANGLADESH

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Abstract

An investigation on the performance of nineteen stem amaranth genotypes was conducted at the experimental field, Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh during November 2007 to March 2008 to select suitable amaranth genotypes for winter season. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The highest primary branch per plant was found in the genotype SA015 (6.83). The thickest stem diameter was observed in the genotype SA023 (22.05 mm) and the thinnest from SA015 (15.28 mm). The highest stem weight/plant was found in the genotype SA026 (205.32 g) and the lowest was in SA027 (79.12 g). The lowest leaf-stem ratio was found in the genotype SA005 (0.32). The genotype SA026 produced the highest stem yield (68.37t/ha) which was at par with SA023. The genotype SA015 was earlier (55.33 days) to flower and the genotype SA005 (104.00 days) was delayed in flowering. The highest edible portion (%) was observed in the genotype SA040 (71.20%) and the lowest was found in the genotype SA026 (51.76). The lowest fibre content (%) was found in the genotype SA040 (0.36%) at 70 days of sowing. The genotypes SA023, SA026, SA028 and SA040 were found promising in respect to amaranth stem production for winter season in Bangladesh.

Keywords: Stem amaranth genotypes, winter season, yield.

Introduction

Amaranth (*Amaranthus tricolor* L.) belongs to the family Amaranthaceae widely grown as vegetable crop. It was originated from South–East Asia and cultivated in different parts of the world including Bangladesh (Chakhartrakan, 2003). The amaranth is said to be native of India (Nath, 1976). It is widely grown as a green vegetable in tropical and subtropical parts of Asia, Africa and Central America (Hardwood, 1980). Amaranth is one of the cheapest leafy vegetables in tropical markets and is often described as the poor man's vegetable. The nutritional value of amaranth is excellent because of its high content of essential micro nutrients. The leaves and tender stem of amaranth are rich in protein, fat, calcium, phosphorus, iron, riboflavin, niacin sodium, β-carotene and ascorbic acid than any other common vegetables (Chowdhury, 1967 and FAO, 1972). The amaranth is being cultivated in an area 10463.56 ha with a total production 67358 tons and the average yield is only 6.88 t/ha (BBS, 2011).

Stem amaranth has been considered as summer vegetable in Bangladesh. Only two

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recognized varieties of stem amaranth (BARI Danta 1 and BARI Danta 2) are available in the country which is cultivated in summer. It was observed that it can be cultivated in winter season too and winter cultivation has appeared to be more profitable as the price is high during that season. No stem amaranth variety has yet been recommended for cultivation in winter season in Bangladesh. On the other hand, Bangladesh is a rich source of land races of stem amaranth (Hossain *et al.,* 1997; Hamid *et al.,* 1989; Hossain and Rahman, 1999). There is an ample scope to improve this crop using the locally available germplasm, and farmers will be benefitted by cultivating improved variety in winter. Stem amaranth is an important vegetable crop but little importance has given for its improvement. Hence the present investigation was, therefore, undertaken to evaluate the performance of stem amaranth genotypes during winter season.

Materials and Methods

A field experiment was conducted at the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh during winter season (November, 2007 to March 2008). The soil of the experimental plot was in Salna series of Shallow Red Brown Terrace Soil (Brammer, 1971; Shaheed, 1984). Nineteen genotypes of stem amaranth were included in the study. Among the 19 amaranth genotypes, 5 (SA033, SA035, SA037, SA039 and SA040) were from Plant Genetic Resource Center (PGRC) of Bangladesh Agricultural Research Institute (BARI), 2 (BARI Danta 1-SA 018 and (BARI Danta 2-SA019) were from vegetable section, Horticulture Research Center, BARI, Gazipur and the remaining 12 (SA 001, SA005, SA006, SA007, SA011, SA014, SA015, SA023, SA026, SA027, SA028, and SA029) were collected from the different parts of the country. All the genotypes were grown in a Randomized Complete Block Design (RCBD) with three replications. The size of the unit plot was 1.5 m x 1.5 m. The seeds were sown continuously in the rows of 30 cm apart. Seedlings were thinned out maintaining a spacing of 30 cm x 10 cm after 15 days of sowing. The crop was manured and fertilized @ 20 tons cow dung (CD) per hectare, Urea, TSP and MP @ 200, 100 and 200 kg per hectare, respectively (Rashid, 1999). All the recommended package and practices were followed to raise good crop. The crop was harvested 60 days after seed sowing. The data from19 amaranth genotypes were recorded on the basis of IBPGR descriptor (Grubbed and Sloten, 1982) during harvesting time on stem pigmentation, leaf pigmentation, leaf shape, leaf margin, inflorescence color, seed color, seed shape, plant height, leaves/plant, number of branches/plant, leaf weight/plant, stem weight/plant, leaf-stem ratio, stem diameter, stem yield (t/ha), edible portion (%), fibre content (%), dry matter content (%), days to first flowering, terminal inflorescence stalk length, axillary inflorescence length and 1000 seed weight from ten randomly selected plants in each plot. Recorded quantitative data on different parameters were analyzed statistically through partitioning the total variance with help of computer software MSTATC program. Analysis of variance was done according to Gomez and Gomez (1984) and the means were separated by using Duncan's Multiple Range Test (DMRT).

Results and Discussion

Plant height

Significant differences were observed in the plant height of stem amaranth genotypes (Table 1). In the present study, plant height ranged from 70.83 to 110.47 cm. The highest plant height was recorded in the genotype SA026 (110.47 cm) which was statistically similar to the genotypes SA005 and SA015 and the lowest plant height was recorded in the genotype SA027 (70.83 cm). Hamid *et al*. (1989) reported that plant height of some exotic and local lines of amaranth varied from 70.20 to 131.60 cm at 49 DAS (days after sowing). The germplasm of amaranth showed a wide range of variability in plant height from 31.00 to 81.5 cm (Varalaksami, 2007). Islam (2002) reported that plant height of amaranth ranged from 11.53 to 160.26 cm. Plant height of present study was similar to Hamid *et al.* (1989) and Islam (2002) and higher than (Varalaksmi, 2007). There was a tendency of different genotypes to show lesser height of plant in winter than that found in summer season. This was might be due to

Table 1. Performance of stem amaranth genotypes in terms of plant height (cm), leaves/ plant, primary branches/plant, stem diameter (mm), stem weight/plant (g), core: peel ratio and leaf: stem ratio of stem amaranth during winter season, 2007

Genotype	Plant height (cm)	Leaves/ plant	Primary branches/ plant	Stem diameter (mm)	Stem weight/plant (g)	Core : Peel ratio	Leaf: Stem ratio
SA001	95.83b-e	17.11de	2.60d	16.92d-g	155.35cd	3.20b-f	0.41fgh
SA005	98.72 a-c	23.44ab	0.00I	18.91b-e	171.23bc	3.47bcd	0.32h
SA006	88.39 b-g	21.93abc	3.67c	20.70abc	167.17c	2.97b-g	0.56ef
SA007	82.86 d-h	19.27b-e	6.00a	15.59fg	99.82gh	2.47fgh	0.87bc
SA011	77.03 gh	24.77a	6.00a	17.49d-g	112.07fg	2.68d-h	0.74cd
SA014	82.03 e-h	17.54cde	1.33ef	19.33a-d	151.37cd	3.36b-e	0.36h
SA015	102.78 ab	19.88b-e	6.83a	15.28g	119.93e-g	2.45fgh	1.10a
SA023	87.33c-g	19.83b-e	0.83fg	22.05a	195.79ab	3.02b-g	0.39gh
SA026	110.47a	25.28a	4.83b	18.86b-e	205.32a	2.11h	0.45fgh
SA027	70.83h	19.08b-e	6.17a	16.11efg	79.12h	2.33gh	0.97ab
SA028	85.33c-h	17.56cde	1.00fg	21.63ab	174.45bc	3.11b-g	0.39gh
SA029	96.83b-d	23.39ab	1.33ef	18.41c-f	168.30c	3.42b-e	0.37gh
SA033	82.44d-h	18.56cde	4.33bc	16.18efg	109.55fg	2.63e-h	0.64de
SA035	82.00d-h	16.00e	4.83b	18.34c-g	130.58def	2.85c-h	0.52efg
SA037	93.72b-f	21.42a-d	2.17de	18.74b-e	164.97c	3.67ab	0.38gh
SA039	90.22b-g	18.11cde	1.10f	16.40d-g	138.68de	2.62e-h	0.41fgh
SA040	80.56f-h	19.94b-e	0.00I	21.50ab	177.60bc	4.33a	0.34h
BARI Danta 1 (SA018)	79.78f-h	19.56b-e	0.00I	20.94abc	165.47c	3.63abc	0.38gh
BARI Danta 2 (SA 019)	93.61b-f	24.39a	0.00I	18.10c-g	152.38cd	3.09b-g	0.41fgh
CV%	8.55	11.13	19.22	8.60	9.46	13.56	15.66

Means followed by same letter(s) in a column did not differ significantly from each other by DMRT at 5% level low temperature in winter season because minimum 18^{0}C temperature is needed during growth which was not available in the winter season (Larkcom, 1991).

Leaves per plant

Significant variation was observed among the stem amaranth genotypes for leaves per plant (Table 1). The maximum number of leaves per plant was recorded in the genotype SA026 (25.28) which was statistically identical to the genotypes SA011, SA019 and similar to the genotypes SA005, SA006, SA029, SA037 and BARI Danta 2 and the lowest leaves per plant was recorded in SA035 (16.00). Hossain *et al*. (1997) reported that leaves per plant at 45 DAS were varied from 22.35 to 37.10, and at 55 DAS it was varied from 32.40 to 56.70. Talukder (1999) reported that leaves per plant at 44 DAS were varied from 25.60 to 26.43. In the present study at 45 DAS leaves per plant ranged from 16.00 to 25.28 which were lower than the previous investigation. This variation might be either due to difference of genotypes used in the study or due to lower temperature in the winter season.

Primary branches per plant

The primary branches per plant were significantly influenced by different genotypes (Table 1). The maximum number of primary branches per plant was found in the genotype SA015 (6.83) which were statistically identical to the genotypes SA007, SA011 and SA027. Mohideen *et al.* (1983) observed the number of branches per plant varied from 0.00 to 8.90 among the eight grain amaranth cultivars. Hossain (1996) reported that the number of branches per plant varied from 0.00 to 11.45 among eleven stem amaranth genotypes. Islam (2002) reported number of primary branches per plant in amaranth ranged from 2.50 to 31.04. In the present study, the primary branches per plant ranged from 0.00 to 6.83 which were lower than the previous reports. This variation might be due to differences in genotype.

Stem diameter

The stem diameter varied significantly in different genotypes (Table 1). The highest stem diameter was found in the genotype SA023 (22.05 mm) and was statistically similar to the genotypes SA006, SA014, SA028 and SA040, while it was the lowest (15.28 mm) in SA015.

Hamid *et al.* (1989) stated that stem diameter of the local germplasm varied from 5.30 to 9.30 mm at 49 DAS. The variations in stem diameter of amaranth were reported by different workers ranged from 16.00 to 22.95 mm (Hossain, 1996) and from 3.0 to 38.0 mm (Islam, 2002). In the present study, the stem diameter ranged from 15.28 to 22.05 mm which was similar to Hossain (1996) and Islam (2002) and higher than Hamid *et al.* (1989).

Stem weight per plant

The genotypes of stem amaranth differed significantly for stem weight per plant (Table 1). The highest stem weight per plant was found in the genotype SA026 (205.32 g) which was statistically similar to the genotype SA023 (195.79 g). Hossain (1996) reported that stem weight per plant at 35 DAS was 28.50 to 40.25 g, at 45 DAS was 39.22 to 89.93 g and at 55 DAS was 84.68 to 247.02 g. Rajagopal *et al.* (1977) reported stem weight per plant was 112.00 to 130.00 g at 35 DAS and 220.00 to 270.00 g at 40 DAS. In the present study, stem weight ranged from 79.1 to 205.32 g which was similar to Hossain (1996) and lower than Rajagopal *et al.* (1977). This variation might be due to either difference of genotypes or harvesting duration or to the variation in prevailing climatic (low temperature in winter season) condition of the experiment or both.

Core: peel ratio

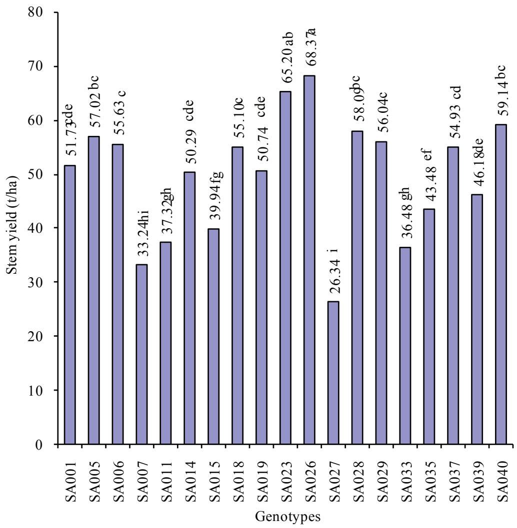
Significant variation was observed in the core: peel ratio of stem amaranth genotypes (Table 1). The highest core: peel ratio was recorded in the genotype SA040 (4.33) which was statistically alike to SA037 and BARI Danta 1. This variation in core: peel ratio in stem amaranth might be due to their genetic makeup.

Leaf: stem ratio

Significant variation was observed among the genotypes of stem amaranth for leaf: stem ratio and ranged from 0.32 to 1.10 (Table 1). The decreasing trend of leaf: stem ratio indicates that stem portion contribute more over leaf portion towards the yield. The leaf: stem ration showed a significant negative relation with yield indicating that high yielders have a low leaf: stem ration and vice versa. Hossain *et al.* (1997) reported that leaf: stem ratio was ranged from 0.59 to 2.27, 0.49 to 1.18 and 0.27 to 0.75 at 35, 45 and 55 DAS respectively. Rajagopal *et al.* (1977) observed leaf: stem ratio in amaranth was 0.90 to 8.20 at 35 DAS and 0.50 to 10.20 at 40 DAS. Talukder (1999) reported that leaf: stem ratio was 0.63 to 0.87, 0.41 to 0.47 and 0.26 to 0.32 at 30, 37 and 44 DAS, respectively. Present finding was similar to Hossain (1996) and Talukder (1999) and lower than Rajagopal *et al.* (1977). Leaf: stem ratio is a useful parameter which can be considered in selecting high stem yielding genotypes.

Stem yield per hectare

The genotypes differed significantly for stem yield per hectare (Figure 1). The highest stem yield per hectare was found in the genotype SA026 (68.37 t/ha) which was statistically similar to the genotype SA023. The lowest stem yield per hectare was found in the genotype SA027 (26.34 t/ha). Hossain (1996) reported that yield per hectare was 9.56 to 19.31, 25.3 to 41.76 and 27.85 to 81.24 t/ha at 35, 45 and 55 DAS, respectively. Quasem and Hossain (1995) reported the yield of 16 local stem amaranth ranged from 15.52 to 54.00 t/ha. Hamid *et al.* (1989) observed the yield of twelve germplasm of amaranth (8 local and 4 exotic) varied from 42.80 to 234.40 t/ha at 49 DAS. In the present study, stem yield per



SA018-BARI Danta-1, SA019-BARI Danta-2

Fig. 1. Stem yield (t/ha) of 19 stem amaranth genotypes during winter season

hectare ranged from 26.34 to 68.37 t/ha which was similar to all the above investigations except Hamid *et al.* (1989). This variation in stem yield might be due to either differences in genotypes or to the favorable climatic condition (lower temperature in the winter season) of the experiment or both.

Edible portion (%)

Significant differences were observed in the edible portion of stem amaranth genotypes (Table 2). The highest edible portion was found in the genotype SA040 (71.20 %) which was closely followed by SA029, SA037, SA014. Mahmud (2011) reported the edible portion of some stem amaranth genotypes ranged from 58% to 75.65%. In the present study, the edible percent ranged from 51.76 to 71.20% which was closer to above finding.

Fibre content

The genotypes showed wide range of variation in fibre content at harvesting (Table 2). The maximum fibre content at harvesting was found in the genotype SA015 (0.63%) which was statistically at par to the genotypes SA033 (0.62%) and SA035 (0.59%). Aykroyd (1963) reported that tender amaranthus contains 1.00% fibre. Edible stem amaranth contains 1.20% fibre (Anon, 1992). In the present study the fibre content of stem amaranth ranged from 0.36 to 0.63% which was lower than the above findings. This variation might be due to their genetic constituents.

Days to first flowering

Significant variation was observed among the genotypes for days to first flowering of stem amaranth (Table 2). The flowering was most delayed in the genotype SA005 (104.00 days) which was statistically different from other genotypes and the earliest (55.33) days were found in the genotype SA015. Hossain (1996) reported that the days to flowering ranged from 51.00 to 113.00 days after sowing. Talukder (1999) reported that the days to flowering ranged from 50.86 to 51.87 days. Islam (2002) reported that days to first flowering ranged from 34.00 to 106.00 days. In the present study the duration of days to first flowering ranged from 61.00 to104.00 days which was higher than Talukder (1999) and similar to Islam (2002) and Hossain's (1996) findings. This variation might be due to either difference in genotypes or to the seasonal variation (lower temperature in the winter season). Late flowering genotypes may be preferred for main cropping season especially for stem purpose.

Terminal Inflorescence stalk length

Significant variation was observed in the terminal inflorescence stalk length of stem amaranth (Table 2). The longest terminal inflorescence stalk was observed in the genotype SA029 (18.47 cm) which was statistically different from other genotypes. The shortest terminal inflorescence stalk was observed in the genotype SA005 (6.33 cm). Islam (2002) reported that the terminal inflorescence stalk length ranged from 2.00-34.10 cm. The amaranth germplasm showed a wide range of variability in terminal inflorescence stalk length of 5.00 to 50.00 cm (Varalaksmi, 2007). The terminal inflorescence stalk length of the present study was within the range of reported findings.

Table 2. Performance of stem amaranth genotypes in terms of edible portion (%), fiber (%), flowering, inflorescence characteristics and 1000 seed weight of stem amaranth during winter season, 2007

Genotype	Edible portion (%)	Fibre (%)	Days to first flowering	Terminal inflorescence stalk length (cm)	Axillary inflorescence length (cm)	1000 seed weight (g)
SA001	65.52abc	0.54cde	92.67b	17.33b	5.33h	0.75gh
SA005	66.67abc	0.45fg	104.00a	6.33i	1.00o	0.93bc
SA006	62.75a-d	0.53de	89.33c	11.67fgh	3.80k	0.85ef
SA007	57.00bcd	0.48ef	58.33i	11.33gh	6.47f	0.75gh
SA011	61.67a-d	0.53de	89.33c	13.33e	3.00m	0.77g
SA014	69.20ab	0.45fg	78.33e	15.33cd	7.00e	0.67i
SA015	51.76d	0.63a	55.33j	12.57ef	10.00b	0.92cd
SA023	63.41a-d	0.41ghi	84.67d	16.33bc	5.67g	0.84f
SA026	51.82d	0.57bcd	61.00h	17.00b	11.33a	0.86ef
SA027	56.30cd	0.40ghi	90.67bc	14.67d	5.67g	0.71hi
SA028	63.62a-d	0.42ghi	91.67bc	14.50d	5.33h	0.94abc
SA029	69.80ab	0.42gh	79.00e	18.47a	8.00d	0.90cde
SA033	60.89a-d	0.62ab	67.00g	10.83h	3.00m	0.99a
SA035	60.52a-d	0.59abc	75.33f	11.83fgh	8.50c	0.93bc
SA037	69.76ab	0.40ghi	81.00e	16.33bc	5.00i	0.69hi
SA039	59.80a-d	0.56bcd	80.00e	11.00h	3.33l	0.78g
SA040	71.20a	0.36i	91.33bc	13.33e	4.50j	0.86def
BARI Danta1 (SA018)	66.80abc	0.38hi	89.33c	12.33efg	4.50j	0.86def
BARI Danta 2 (SA019)	61.98a-d	0.54cd	90.00bc	7.00i	1.67n	0.98ab
CV%	10.34	6.37	1.94	4.42	2.53	3.87

Means followed by same letter(s) in a column did not differ significantly from each other by DMRT at 5% level

Axillary inflorescence length

Significant variation was observed in the axillary inflorescence length of stem amaranth (Table 2). The highest length of axillary inflorescences was found in the genotype SA026 (11.33 cm) which was statistically different from other genotypes and the lowest value was recorded in the genotype SA005 (1.00 cm) which was also statistically different from other genotypes. The germplasm of amaranth showed a wide range of variability in the length of axillary inflorescence of 0.20 to 5.00 cm (Varalaksmi, 2007). Axillary inflorescence length of the study ranged from 1.00 to 11.33 cm which was higher than above investigation. This might be due to their genetic constituents or ecological variation.

1000 seed weight

Thousand (1000) seed weight of different genotypes of stem amaranth varied significantly (Table 2). The maximum weight of 1000 seed was recorded in the genotype SA033 (0.99 g) closely followed by SA019

(0.98 g) and SA028 (0.94 g) and the minimum weight of 0.67 g was noted in the genotype SA014 (0.67g). Islam (2002) reported that 1000 seed weight of amaranth ranged from 0.30 to 1.22g. Talukder (1999) reported that 1000 seed weight of stem amaranth ranged from 0.90 to 1.20 g. The 1000 seed weight of the study ranged from 0.67 to 0.99 g which was with in the range of Islam (2002) and little lower than Talukder (1999). This variation might be due to their genetic makeup or seasonal variation.

Conclusion

Wide variabilities exist among the amaranth genotypes used in the present experiment. Those variabilities could be used for further improvement program of amaranth in our country. It is concluded from the experiment that yield was mainly contributed by plant height, number of leaves, leaf weight, stem weight, leaf: stem ratio and stem diameter. The stem weight and stem diameter had maximum direct effect on yield. Considering the above mentioned characteristics three amaranth genotypes viz. SA023, SA026, and SA040 were found suitable for cultivation in winter season of Bangladesh.

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