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Field evaluation of *Amaranthus* species for foliage yield and its component characters

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Abstract

Twenty two genotypes collected from different parts of Odisha and Andhra Pradesh and maintained at M.S Swaminathan School of Agriculture, Gajapati, Odisha and subjected to evaluation for 17 quantitative characters and 5 qualitative characters. The data were analyzed for the character viz., plant height (cm), plant fresh weight (g), number of leaves per plant, number of branch per plant, leaf length (cm), leaf width (cm), leaf area (cm²), petiole length (cm), stem fresh weight (g), root fresh weight (g), fresh leaf weight (g), leaf stem ratio, germination percentage (%), harvest index %, foliage yield (kg per plot), biological yield (kg per plot), crop duration (days), dry matter percentage of plant, TSS, chlorophyll and fibre content.

This analysis of variance revealed that mean sum of squares due to genotypes was highly significant for all the studied characters. This is an indication of existence of sufficient variability among the genotypes for foliage yield and its component traits. Highest yield mean performance seen in genotype AMAR- 07 local collection from Pathpatnam. AMAR- 07 was superior among all the genotype for most of the quantitative characters plant height, petiole length, leaf length, leaf width, leaf stem ratio, biological yield, foliage yield .whereas AMAR-01 was superior among all the genotype for most of the qualitative characters viz. dry matter % and fibre content. AMAR- 17 was superior among all the genotype for most of the qualitative characters viz. chlorophyll b and total chlorophyll content.

Keywords: Amaranthus, foliage yield, genotype

Introduction

Amaranthus is one of the important and popular leafy vegetable of India. Amaranthus (*Amaranthus spp*) family Amaranthaceae, sub family Amaranthoideae and genus Amaranthus. The genus Amaranthus includes 50-60 species, cultivated for leaf as well as for grains and few are wild species. Main vegetable type of leaf amaranth is *Amaranthus tricolor L.*, originated in South East Asia, particularly in India. (Rai and Yadav, 2005) [2]. Amaranth plants are fast growing, tall, soft-wooded annuals, extremely variable, erect to spreading with strongly branched tap root.

The height of mature plants varies between 0.3 m and 2.5 m, depending on the species, growth habit and environment. Pollination is predominantly autogamous in amaranth. Its flowers are unisexual, small, with stamens at the apex of the glomerules and pistils. It has a high rate of photosynthesis and excellent water use efficiency at high temperatures and high radiation intensity and has a remarkable capacity of rejuvenation after each cut. Amaranthus is an under-exploited leafy vegetable and is often described as "poor man's vegetable". Amaranthus is a rich source of nutrients it serves as an alternative source of nutrition for people in developing countries. (Shukla *et al.* 2003) [3]. It has been rated equal or superior in taste to spinach. Tender stems and leaves contains moisture (85.70 %), protein (4.0 g), fat (0.50 g), carbohydrates (6.30 g), calcium (397.0 mg), phosphorus (83.0 mg), vitamin A (9200IU), and vitamin C (99 mg), (Rai and Yadav, 2005) [2], potassium (6.4 to 6.7 g/kg), calcium (0.73 to 1.9 g/kg), magnesium (2.8 to 3.0 g/kg), zinc (434.7 to 1230 mg/kg) with an average of, iron (783-2306 mg/kg), manganese (66.7-155 mg/kg) and nickel (89.3 to 321.3 mg/kg) (Shukla *et al.* 2006) [4]. It is also a good source of dietary fiber. Antioxidants like beta-carotenoid (90 - 200 mg kg-1) and ascorbic acid (about 28 mg/100 g) compared to any other leafy vegetables. The availability of genetic variation among different strains and within strains provides great scope for crop improvement through judicious selection and breeding to develop the desired genotype. The knowledge of nature and degree of existing in germplasm is prerequisite in breeding programme of Amaranthus for effective selection of superior genotypes. Leafy vegetables are very well recognized at local level but unfortunately less or no systematic work yet to be initialized under Odisha region. Due to the higher yield potential, higher nutritional content with local adaptability, the systematic work will be initialized to exploit immense potential of leafy vegetables.

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Since such studies are meager particularly under Odisha conditions, the present investigation was carried out with a set of varieties and advanced lines of amaranthus.

Materials and Methods

The present investigation was conducted in The present was conducted in Bagushala village, M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Gajapati, Odisha during kharif season 2017-2018. The experiment was conducted in the randomized block design with 22 genotypes replicated thrice. Seeds were sown on 2nd August 2018. Spacing of 30 cm x 20 cm was uniformly adopted. A fertilizer dose of 40 kg N, 25kg P₂O₅ and 25 kg K₂O per ha was applied. The total amount of phosphorus with 25 kg of nitrogen and 12.5 kg of K₂O was applied to the soil before sowing. Remaining 25 kg of nitrogen and 12.5 kg of potash was applied in two-splits. All other cultural practices were uniformly adopted according to recommended packages. The data recorded for various characters were subjected to statistical analysis. The analysis was carried out separately for each trait following the procedure of randomized block design analysis (Panse and Sukhatme, 1954).

Treatment Details

Table 1: Collected genotypes from different sources

Serial no.	Treatment	Source
1	AMAR - 01	Local collection from Gunupur
2	AMAR - 02	Local collection from bhubaneswar
3	AMAR - 03	Local collection from, Boudh
4	AMAR - 04	Local collection from, Koraput
5	AMAR - 05	Local collection from, Kalahandi
6	AMAR - 06	Local collection from, Boudh
7	AMAR - 07	Local collection from, Pathpatnam
8	AMAR - 08	Local collection from, Cuttack
9	AMAR - 09	Local collection from, Banki
10	AMAR - 10	Local collection from, Boudh
11	AMAR - 11	Local collection from, Boudh
12	AMAR - 12	Local collection from, Koraput
13	AMAR - 13	Local collection from, Kalahandi
14	AMAR - 14	Local collection from, Boudh
15	AMAR - 15	Local collection from, Bhubaneswar
16	AMAR - 16	Local collection from, Bhubaneswar
17	AMAR - 17	Local collection from, Boudh
18	AMAR - 18	Local collection from, Boudh
19	AMAR - 19	Local collection from, Koraput
20	AMAR - 20	Local collection from, Bagushala
21	AMAR - 21	Local collection from, Paralakhemundi
22	AMAR - 22	Local collection from, Yelluru, Andhra pradesh

Result and Discussion

A reference to Table 2 showed that the treatments

Table 2: Mean performances of 22 genotypes for foliage yields and its component characters.

Treatment	Plant Height (cm)	Plant Fresh Weight (g)	Root Fresh Weight (g)	Stem Fresh Weight (g)	Fresh Leaves Weight (g)	No. of Branches per plant	No. of Leaves per plant	Petiole Length (cm)	Leaf Length (cm)	Leaf Width (cm)	Leaf Area (cm ²)	Leaf Stem Ratio	Germination Rate (%)	Crop Duration (days)	Harvest Index (%)	Biological Yield (kg/plot)	foliage Yield (kg / plot)
AMAR - 1	12.23	7.00	0.52	3.63	3.53	4.40	9.40	3.54	2.97	3.54	27.09	3.40	86.67	40.00	57.00	11.79	1.30
AMAR - 2	20.00	9.03	0.53	3.81	3.42	3.83	8.93	4.60	4.46	4.13	32.45	3.75	91.33	28.33	37.87	9.44	1.24
AMAR - 3	19.83	6.34	0.53	4.66	1.81	3.40	9.77	4.33	3.37	2.67	24.39	4.03	89.00	32.67	35.82	8.73	0.74
AMAR - 4	26.16	4.15	0.46	3.59	1.58	2.57	13.53	4.39	3.31	4.39	10.59	3.58	90.00	31.67	39.14	7.69	0.90
AMAR - 5	23.99	7.73	0.72	3.50	2.77	4.93	16.47	3.33	3.47	3.33	19.00	3.50	90.67	29.67	35.76	10.15	0.89
AMAR - 6	18.33	3.65	0.41	3.72	1.29	5.33	15.67	3.13	3.09	2.46	11.47	2.96	91.67	28.00	47.75	10.68	0.82
AMAR - 7	23.23	7.17	0.43	3.41	2.66	3.57	8.03	4.30	5.77	4.30	20.97	4.70	92.33	29.00	37.08	12.72	2.17
AMAR - 8	21.00	5.50	0.40	3.59	1.13	6.40	10.13	3.49	3.42	2.43	16.55	4.13	89.67	31.00	45.08	10.53	0.71

significantly differed for all the characters showing that mean performances of all quantitative characters for foliage yield and its component characters.

Mean performance of genotype for different characters

Observation was recorded on the ten randomly selected plants, for different genotypes and was used for calculating the mean performance for different traits. The mean performances of all the traits for the twenty two genotypes are shown in the Table - 2 and result is described as below:

Plant height (cm)

Plant height ranged from 12.23 to 26.18 with an overall mean of 19.26 cm. Maximum plant height was recorded in the genotype AMAR – 13 (26.18 cm) followed by AMAR - 04 (26.16 cm), AMAR – 05 (23.99 cm) and AMAR – 07 (23.23cm.) However, minimum plant height was noticed in genotype AMAR – 01 (12.23cm).

Plant Fresh Weight (g)

Fresh weight of plant ranged from to 13.30 with 3.23 overall mean of 6.47 g. Maximum plant fresh weight recorded in genotypes AMAR-16 (13.30 g) followed by AMAR-17 (10.27 g) and AMAR-02(10.25 g) whereas, the minimum fresh weight of plant recorded in AMAR-11(3.23 g).

Fresh Root Weight (g)

Fresh weight of root ranged from 0.38 to 0.92 with an overall mean of 0.53 g. Maximum fresh weight recorded in genotypes AMAR-16 (0.92 g) followed by AMAR-21 (0.80 g) and AMAR-17 (0.79 g) whereas, the minimum fresh weight of plant recorded in AMAR-05 (3.23 g).

Fresh Stem Weight (g)

Fresh stem weight of ranged from 5.92 to 3.32 with an overall mean of 3.99g. Maximum stem fresh weight recorded in genotypes AMAR-17 (5.92 g) followed by AMAR-21 (5.40 g) and AMAR-09 (4.73 g) whereas, the minimum fresh weight of plant recorded in AMAR-22 (3.32 g).

Fresh Leaf Weight (g)

Leaf weight is ranged from 1.13 to 3.53 with overall mean of 2.15 g. Maximum Leaf weight 3.53 g was recorded in genotype AMAR-01 followed by AMAR-15 (3.43 g), AMAR-16 (3.41 g) Whereas, minimum leaf weight was recorded in genotype AMAR- 08 (1.13 g).

Number of branch per plant

Highest number of branches per plant recorded in genotypes AMAR-08 (6.4) followed by AMAR – 18 (5.40), AMAR-06 (5.33).Whereas, minimum no. of branches per plant recorded in AMAR- 10, AMAR- 20.

AMAR - 9	20.20	4.47	0.42	4.73	1.32	3.27	11.47	3.99	4.78	3.32	28.33	3.62	93.67	28.00	35.94	8.66	1.44
AMAR - 10	14.83	4.23	0.44	3.59	1.39	1.00	7.33	4.19	3.90	4.19	30.10	3.42	93.00	25.00	47.63	10.77	1.14
AMAR - 11	24.47	3.23	0.39	3.87	1.35	5.53	12.93	3.21	3.66	2.21	24.37	3.68	92.33	31.33	57.99	9.83	1.31
AMAR - 12	22.30	4.77	0.47	3.48	1.42	3.63	13.93	3.56	3.66	2.29	14.53	3.76	94.67	27.00	58.45	10.87	1.09
AMAR - 13	26.17	4.33	0.43	3.56	1.56	4.33	19.47	3.39	3.45	2.41	18.50	4.07	95.67	32.70	52.64	4.34	1.13
AMAR - 14	18.17	4.43	0.50	3.95	1.31	3.33	11.33	3.69	4.35	3.36	10.53	3.44	97.00	32.67	65.63	10.58	0.96
AMAR - 15	13.33	4.11	0.41	3.42	3.43	3.37	9.00	3.59	3.87	2.59	20.01	4.43	95.00	26.00	67.25	11.04	1.35
AMAR - 16	17.60	13.30	0.92	3.46	3.41	3.37	9.63	3.94	3.38	2.72	16.79	3.41	92.00	29.67	23.38	10.21	1.20
AMAR - 17	18.50	10.25	0.79	5.92	3.15	3.60	5.67	3.22	5.28	3.22	25.05	3.52	93.00	30.33	34.96	11.40	1.08
AMAR - 18	15.00	7.53	0.63	4.70	2.27	5.40	10.00	3.80	4.43	2.80	11.10	3.94	89.67	31.33	33.30	7.89	0.89
AMAR - 19	20.97	8.37	0.52	4.37	1.90	2.33	10.37	3.61	4.35	2.61	20.77	4.35	93.00	26.00	53.48	8.72	1.61
AMAR - 20	18.50	4.35	0.55	4.14	1.13	1.00	12.53	3.99	5.35	3.12	15.85	3.33	93.33	34.33	42.16	9.35	0.93
AMAR - 21	13.00	8.13	0.80	5.40	2.39	3.57	3.93	3.11	4.21	3.11	21.22	3.76	92.33	26.33	29.32	6.20	0.84
AMAR - 22	16.00	10.27	0.38	3.32	3.07	1.00	11.47	2.86	6.10	2.80	16.05	3.40	91.67	35.33	30.24	10.02	1.39
CD (p = 0.05)	4.45	1.01	0.20	0.83	0.44	0.41	3.23	0.83	1.29	0.30	2.27	0.44	3.67	5.02	8.10	1.18	0.37
CV (%)	14.03	9.46	23.35	12.62	12.35	6.94	17.91	13.69	19.12	5.98	6.95	12.35	2.42	10.07	11.18	7.45	19.89

Number of leaves per plant

Number of leaves per plant ranged between 3.93 to 19.47 with an average mean of 10.23. Maximum number of leaves per plant recorded in genotype AMAR-13 (19.47) followed by AMAR-05 (16.47), AMAR-07 (15.67) While genotype AMAR-21 (3.93) was noted for minimum number of leaves per plant.

Petiole Length (cm)

The range of petiole length lies between 2.86 to 4.60 with an overall mean of 3.69cm. The highest petiole length 4.60 cm was recorded in genotype AMAR-02, Whereas, it was found statistically *at par* with genotypes AMAR-03 (4.39 cm) and AMAR-04 (4.33cm). Genotype AMAR-22 (2.86 cm) was noted for minimum petiole length.

Leaf Length (cm)

Leaf length varied from 2.97 to 6.10 with an overall mean of 4.12 cm. The highest leaf length 6.10 cm was recorded in genotype AMAR-22. However, it was found statistically *at par* with genotypes *viz.* AMAR-07 (5.77cm), AMAR-20 (5.35 cm) and AMAR-17 (5.28 cm). Genotype AMAR-1 (2.97cm) was noted for minimum leaf length.

Leaf Width (cm)

Leaf width ranged from 2.21 to 4.39 with an overall mean of 3.09 cm. The highest leaf width 4.39 cm was recorded in genotype AMAR-04. However, it was found statistically *at par* with genotypes *viz.* AMAR-07 (4.30 cm), AMAR-02 (4.13 cm), AMAR-10 (4.19 cm), whereas the lowest leaf width 2.21 cm was recorded in genotypes AMAR-11.

Leaf Area (cm²)

Leaf area ranged from 10.53 to 32.45 with an overall mean of 18.70 cm². Maximum Leaf area 32.45cm² was recorded in genotype AMAR-02. Followed by AMAR-09 (28.33 cm²), AMAR-01 (27.09 cm²) and AMAR-17 (25.05 cm²). Genotype AMAR-14 (10.53 cm²) were noted for minimum Leaf area.

Leaf Stem Ratio

Leaf stem ratio ranged from 2.96 to 4.70 with an overall mean of 0.87. Maximum Leaf stem ratio 4.70 was recorded in genotype AMAR-07. However, it was found statistically *at par* with genotypes AMAR-15 (4.43), AMAR-19 (4.35), AMAR-13 (4.07).Whereas, minimum Leaf stem ratio 2.96 was recorded in genotype AMAR-06.

Germination Rate (%)

Germination rate ranged from 86.67 to 97% with an overall mean of 92.17% .Maximum germination rate 97% was

recorded in genotype AMAR-14, followed by AMAR-13(95.67%), AMAR-15(95%), and AMAR-12 (94.67%), minimum germination rate recorded in genotypes AMAR-01.

Crop Duration (days)

Crop duration ranged from 25 to 40 days with an overall mean of 30.29. Maximum crop duration 40 days was recorded in genotype AMAR-01. However, it was found statistically *at par* with genotypes AMAR-22 (35.33), AMAR-20 (34.33), AMAR-13 (32.70).Whereas, minimum crop duration 25 days was recorded in genotype AMAR-10.

Harvest Index (%)

Harvest index % ranged from 23.38 to 67.25 % with an overall mean of 30.29. Maximum harvest index % was recorded in genotype AMAR-15. However, it was found statistically *at par* with genotypes AMAR-14 (65.63%), AMAR-12 (58.45%), AMAR-11(57.99%).Whereas, minimum harvest index % was recorded in genotype AMAR-16.

Biological Yield (kg/plot)

Biological yield per plot ranged from 4.34 to 12.72 kg/plot with an overall mean of 9.62 kg/plot. Maximum biological yield per plot 12.72 kg/plot was recorded in genotype AMAR-07.Followed by AMAR-01(11.79kg/plot), AMAR-17 (11.40 kg/plot) and AMAR-15 (11.40 kg /plot) and whereas, minimum biological yield per plot found in AMAR-13 (4.34kg/plot).

Foliage yield (kg/plot)

Foliage yield per plot ranged from 0.71 to 2.17 kg/plot with an overall mean of 1.14 k/plot. Maximum foliage yield per plot 2.17 kg/plot was recorded in genotype AMAR-07, followed by AMAR-19 (1.61 kg/plot), AMAR-15 (1.35 kg/plot) and AMAR- 01 (1.30 kg/plot). Whereas, minimum foliage yield per plot found in AMAR-08 (0.71kg/plot).

Mean performance of genotype for different qualitative characters

Observation was recorded on the ten randomly selected plants, for different genotypes and was used for calculating the mean performance for different traits. The mean performances of all the traits for the twenty three genotypes are shown in the table - 3 and result is described as below:

Fibre content (%)

Maximum fibre content recorded in genotype AMAR-01 (5.11%) followed by AMAR-05 (3.72 %) and AMAR-07, AMAR-2 (3.25%). While, minimum fibre content noticed in AMAR-12 (1.02 %) with an overall mean of 2.61%.

Chlorophyll a (mg g-1)

Maximum Chlorophyll a content recorded in genotype AMAR-08 (1.89mg) followed by AMAR-12 (1.84 mg), AMAR-17 (1.80 mg), and AMAR-11 (1.74 mg), While, Chlorophyll a minimum content noticed in AMAR-19 (0.74 mg) with an overall mean of 1.51 mg.

Chlorophyll b (mg g-1)

Maximum Chlorophyll b content recorded in genotype AMAR-17 (0.89 mg) followed by AMAR-18 (0.80 mg), AMAR-16 (0.78 mg), and AMAR-10 (0.73 mg), While, Chlorophyll b minimum content noticed in AMAR-01 (0.37 mg) with an overall mean of 1.04 mg.

Total chlorophyll (mg g-1)

Maximum total chlorophyll content recorded in genotype AMAR-17 (2.65 mg) followed by AMAR-12 (2.39mg), AMAR-09 (2.37 mg), and AMAR-16 (2.23 mg), While, Total

chlorophyll minimum content noticed in AMAR-20 (1.10 mg) with an overall mean of 1.97 mg.

TSS (%)

Maximum TSS content recorded in genotype AMAR-15 (17.94 %) followed by AMAR-22 (15.11 %), AMAR-19 (14.18%), and AMAR-16 (13.95%), While, TSS minimum content noticed in AMAR-18 (7.74 %) with an overall mean of % 11.99%.

Dry matter (%)

The dry matter percentage of plant ranged from 3.93to 10.12 with an overall mean of 10.35 %. The maximum dry matter percentage found in AMAR-1(10.12%). however, it was found statistically *at par* with genotypes *viz.* AMAR-12 (9.173%), AMAR-21 (8.677 %) and AMAR-17 (7.823%) minimum dry matter percentage of plant found in AMAR-06 (3.93%).

Table 3: Mean performances of qualitative characters for foliage yield and its component characters.

Genotypes	TSS	Dry Matter %	fibre	Chl a	Chl b	Total Chl
AMAR - 1	10.113	10.12	5.11	1.26	0.26	1.44
AMAR - 2	8.92	5.093	3.259	1.51	0.4	1.92
AMAR - 3	11.793	5.417	2.49	1.31	0.4	1.72
AMAR - 4	10.96	6.153	2.627	1.06	0.64	1.75
AMAR - 5	12.58	5.04	3.725	0.81	0.3	1.11
AMAR - 6	11.66	3.93	2.485	1.31	0.78	2.21
AMAR - 7	10.327	7.503	3.608	0.85	0.42	1.23
AMAR - 8	13.28	4.407	2.849	1.23	0.34	1.57
AMAR - 9	10.367	7.65	1.779	1.89	0.46	2.37
AMAR - 10	13.36	4.753	2.84	1.09	0.81	1.9
AMAR - 11	13.02	5.507	2.647	1.74	0.47	2.21
AMAR - 12	13.013	9.173	1.02	1.84	0.54	2.39
AMAR - 13	12.193	4.127	2.691	1.5	0.66	2.19
AMAR - 14	13.64	4.833	1.801	1.34	0.25	1.59
AMAR - 15	17.94	4.76	1.582	1.73	0.46	2.21
AMAR - 16	13.953	5.09	1.702	1.53	0.73	2.23
AMAR - 17	9.153	7.823	2.833	1.8	0.89	2.65
AMAR - 18	7.74	5.373	1.641	1.25	0.8	2.15
AMAR - 19	14.187	4.977	2.799	0.74	0.41	1.28
AMAR - 20	10.733	6.127	1.652	0.85	0.2	1.1
AMAR - 21	9.8	8.677	2.378	1.6	0.47	2.12
AMAR - 22	15.113	5.08	1.737	1	0.31	1.31
CD (p = 0.05)	0.66	3.37	0.3	0.15	0.1	4.04
CV	3.35	22.25	7.3	6.95	13	19.74

Conclusion

Considering the above parameters In present investigation, AMAR- 07 was superior among all the genotype for most of the quantitative characters petiole length, leaf length, leaf width, leaf stem ratio, biological yield, foliage yield . AMAR 13 was superior for plant height and no. of leaves per plant. Whereas AMAR-01 was superior among all the genotype for most of the qualitative characters *viz.* dry matter % and fibre content. AMAR- 17 was superior among all the genotype for most of the qualitative characters *viz.* chlorophyll b and total chlorophyll. These two genotypes can be utilized for further breeding programme for selection of variety in Odisha condition. The AMAR-07 was superior among all the genotype for most of the quantitative and qualitative characters.

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