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Mean performance of leafy *Amaranthus* genotypes under different seasonal conditions in Malwa region of Madhya Pradesh

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Abstract

The present investigation was carried out during *Kharif* and *Rabi* seasons of the year 2018-19 under State Plan Project, DARP, RVSKVV, College of Agriculture, Indore under dryland condition to evaluate the mean performance of the *Amaranthus* accessions under different seasonal conditions, providing insights into their adaptability and yield potential for leaf production. The present study material consisted of nine genotypes of *Amaranthus spp.* including three released varieties and six local accessions and evaluated in dryland condition. Farmyard manure (FYM) was applied at a rate of 10 t/ha, along with a basal dose of NPK fertilizers (30 kg N, 20 kg P, 10 kg K/ha.). Observations were recorded on various yield and its related traits. In leafy *Amaranthus*, overall, CO-1 KERALA AMA 17-18-102 were among the best-performing genotype in terms of growth, vigour and yield in both seasons.

Keywords: Seasonal variation, *Kharif*, *Rabi*, leaf attributing traits, yield

Introduction

Amaranthus, a highly nutritious leafy and pseudocereal grain crop, belongs to the family *Amaranthaceae* and reported as highly cross pollinated crop. It has gained renewed attention as a promising food crop due to its resistance to heat, drought, diseases and pests. Additionally, its unique C-4 metabolic pathway contributes to its wide adaptability across diverse environmental conditions (Kaul *et al.* 1996) ^[5]. The Himalayan region is considered as the center of diversity for this crop, and it is mainly grown for grain production in Uttarakhand. Cultivation of *Amaranth* has also expanded in parts of Maharashtra, Gujarat, and Madhya Pradesh, contributing to nutritional security in these areas. This crop has the potential to increase production with limited inputs and can thrive across a wide range of agro-ecological zones (Jangir *et al.* 2019) ^[4]. Despite the introduction of various strains through collection and selection programs, there is a lack of comprehensive evaluation studies on yield, attributing traits, and qualitative parameters across different seasons (Shukla and Singh 2003) ^[13]. In the context of climate change and the growing expansion of arid areas worldwide, farmers are increasingly seeking crops with nutritional benefits that require minimal inputs. Such crops can be utilized in multiple ways and can grow alongside other crops, helping to enhance productivity in dry areas, where irrigation is limited. Recognizing the significance of nutritious crops like *Amaranthus* and the need to promote their cultivation across different regions of the country, an experiment was conducted to evaluate both the quantitative and qualitative traits of various leafy *Amaranth* varieties. The study aimed to assess these traits across multiple seasons to better understand their performance under varying environmental conditions. This research is essential for identifying the most suitable varieties for different agro-ecological zones, thereby contributing to improved crop productivity and nutritional security.

Materials and Methods

The experimental material for this study consisted of nine genotypes of *Amaranthus spp.*, including three released varieties and six accessions from the local collection of Madhya Pradesh. During the period of 2017-18, these accessions were identified for leaf production and

its attributing traits specifically in the *Kharif* and *Rabi* seasons. Following this identification, an experiment was conducted under the State Plan Project, DARP, RVSKVV, College of Agriculture, Indore, during the year 2018-19 respectively, covering both *Kharif* and *Rabi* seasons. The experimental design used was a Randomized Complete Block Design with three replications. In each replication, 2x2 meter square plots were arranged, with row spacing of 40 cm and plant spacing of 15 cm. Under dryland conditions, farmyard manure (FYM) was applied at a rate of 10 t/ha, along with a basal dose of NPK fertilizers (30 kg N, 20 kg P, 10 kg K/ha.). These fertilizers were applied using urea, single superphosphate, and muriate of potash, respectively. The urea was split into three doses-one basal and the remaining two were applied at each harvest, i.e., 32-34 and 55 days after sowing. Irrigation scheduling was not required in the *Kharif* season, but in the *Rabi* season, irrigation was applied immediately after sowing with a minimum of two irrigations at 15 days intervals thereafter. All good agricultural practices were followed to ensure healthy crop growth. Leafy Amaranthus was harvested at 34 and 32 days after sowing in the *Kharif* and *Rabi* seasons respectively, by clipping the shoots 15 cm above ground level. Quantitative and qualitative traits were recorded in both seasons and the data were analyzed statistically. The study aimed to evaluate the mean performance of the Amaranthus accessions under different seasonal conditions, providing insights into their adaptability and yield potential for leaf production.

Results and Discussion

The data analysis of leafy Amaranthus under dryland condition during the *Kharif* and *Rabi* seasons of the year 2018-19, revealed significant variability in growth, yield, and quality across genotypes, were shown in Table-1 & Table-2. In *Kharif* season, germination percentage ranged from 83.67% to 97.67%, with INDORE AMA 17-18-131 showing the highest (97.67%). INDORE AMA 17-18-131 also exhibited the fastest germination and highest vigour indices. While in *Rabi* season, germination percentage ranged from 80.00% to 95.00%, with INDORE AMA 17-18-131 recording the highest (95.00%). Vigour index-1 ranged from 671.83 to 926.55, with INDORE AMA 17-18-131 achieving the highest vigour (926.55). Vigour index-2 varied from 33.12 to 64.43, with the highest recorded in INDORE AMA 17-18-131 (64.43). Days taken for germination varied from 6.67 to 9.33 days, with the quickest germination in INDORE AMA 17-18-131 (6.67 days) and CHINDWARA AMA 17-18-124 (6.67 days). Similar findings were also reported by Gimplinger *et al.* (2007) [2] for germination percentage. The higher germination percentage during *Kharif* season, might be due to the prevalence of favourable conditions and the genotype's interaction with the environment.

During *Kharif* season, in terms of plant height, the genotype INDORE AMA 17-18-131 consistently outperformed other genotypes at 30, 40, and 70 DAS, reaching a maximum height of 58.56 cm. Leaf traits varied significantly, with RENUSHREE KERALA AMA 17-18-101 having the longest leaf length (6.34 cm), RENUSHREE KERALA AMA 17-18-101 also showing the widest leaves (4.32 cm), whereas CO-1 KERALA AMA 17-18-102 showing the thickest stems (3.54 cm), and CHINDWARA AMA 17-18-125 having the smallest dimensions. CO-1 KERALA AMA 17-18-102 also recorded the

highest leaf area (26.62 cm²), leaf weight (13.19 g), stem weight (45.13 g), plant weight (103.44 g), and chlorophyll content (41.69), while NAGPUR AMA 17-18-129 had the lowest values for leaf weight (4.75 g), and stem weight (15.15 g). The highest leaf yield was recorded in CO-1 KERALA AMA 17-18-102 (10.13 kg/plot and 253.25 q/ha.), while the lowest was recorded in HOSHANGABAD AMA 17-18-123 (3.77 kg/plot and 94.25 q/ha.). The leaf: stem ratio was highest in RENUSHREE KERALA AMA 17-18-101 (0.42) and lowest in ANUSHREE AMA 17-18-105 (0.24). These results highlight the significant genetic variability and potential for selection in breeding programs to improve key traits in leafy Amaranthus.

During *Rabi* season, plant height, leaf length, and other vegetative traits such as leaf width, petiole length and number of leaves also varied widely, with INDORE AMA 17-18-131 recording the highest values. For instance, plant height at 70 DAS varied from 47.29 cm to 77.68 cm, with INDORE AMA 17-18-131 showing the tallest plants (77.68 cm). CO-1 KERALA AMA 17-18-102 showing the thickest stems (4.23 cm). Yield parameters like leaf yield (15.56 kg/plot and 389.00 q/ha.) and chlorophyll content (42.43) were highest in CO-1 KERALA AMA 17-18-102, which also showed superior values for stem weight (67.76 g) and plant weight (160.68 g). Conversely, HOSHANGABAD AMA 17-18-123 and CHINDWARA AMA 17-18-125 recorded the lowest values across several traits. Overall, CO-1 KERALA AMA 17-18-102 were among the best-performing genotype in terms of growth, vigour, and yield in both seasons. The similar findings with growth parameters were also confirmed by Wu *et al.* (2000) [17] for plant height, number of leaf and maturity. Shukla *et al.* (2006) [14] for foliage yield for two successive seasons. Rivelli *et al.* (2008) [11] for biomass yield. Mandal and Dhangarh (2012) [6] and Mandal *et al.* (2013) [7] for leaf stem ratio and foliage yield. Mbwanbo *et al.* (2015) [8] for foliage yield over the two seasons. Sarker *et al.* (2015) [12] for biological yield. Shukla *et al.* (2016) [15] for foliage yield. Panda *et al.* (2017) [9] for plant height, number of leaves per plant, stem girth, leaf length, leaf breadth, petiole length, leaf area, stem weight, leaf weight, leaf-stem ratio and yield per plant. Tejaswini *et al.* (2017) [16] for leaf length, leaf width, leaf area index, leaf weight per plant, total foliage yield per plant and total chlorophyll content. Jangde *et al.* (2018) [3] for plant height, number of branches per plant, stem base diameter, number of leaves per plant, leaf length, leaf width, leaf area, petiole length, plant fresh weight, fresh leaf weight, fresh stem weight, leaf stem ratio and leaf yield (kg/plot). Dinssa *et al.* (2019) [1] for vegetable yield over the two seasons. Pharle *et al.* (2019) [10] for duration of harvesting in Amaranthus. The plant height is considered as one of the important trait for growth and vigour of the plant. In present experiment, the genotypes exhibited significant differences for the plant height at different stages of the growth in both the seasons. The genotypes showed higher stem diameter, taken into account for further work in stem diameter ratio. The higher stem yield is a contributing trait to leaf yield, which is also influenced by the number of branches, total plant weight, and number of leaves. An increase in the number of leaves and leaf weight directly contributes to an increase in total foliage yield. The genotypes perform better during the *Rabi* season, compared to the *Kharif* season, primarily due to the favourable environmental conditions and the drought tolerance nature of the genotypes.

Table 1: Data on the mean performance and yield potential of *leaf* Amaranthus in the *Kharif* season of the year 2018-19 under dryland condition.

Genotypes	Germination %	Days taken for germination	Vigour Index-1	Vigour Index-2	Plant height 30DAS (cm)	Plant height 40DAS (cm)	Plant height 70DAS (cm)	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	Stem diameter (cm)	Leaf area (cm ²)
RENUSHREE KERALA AMA 17-18-101	87.33	6.67	597.90	39.05	16.55	27.61	43.51	6.34	4.32	4.43	2.46	25.52
CO-1 KERALA AMA 17-18-102	83.67	4.67	570.43	43.96	11.57	22.69	39.83	5.47	4.27	3.96	3.54	26.62
ANUSHREE AMA 17-18-105	85.00	5.33	564.53	40.43	10.39	21.36	35.53	5.73	3.88	3.70	3.27	22.11
HOSHANGABAD AMA 17-18-123	85.67	5.67	544.45	30.13	12.57	18.42	38.47	3.53	2.86	2.40	2.15	12.44
CHINDWARA AMA 17-18-124	88.33	4.67	555.74	31.79	18.39	21.94	42.40	3.27	2.49	2.55	2.13	13.32
CHINDWARA AMA 17-18-125	90.00	4.33	819.56	46.48	19.56	29.67	51.19	3.13	1.29	2.13	2.62	12.18
NAGPUR AMA 17-18-129	85.33	5.33	538.25	33.76	13.91	21.33	43.52	3.58	2.66	2.43	2.08	14.16
INDORE AMA 17-18-130	94.00	4.67	595.50	38.30	13.69	20.34	33.68	4.92	3.39	3.62	3.39	19.13
INDORE AMA 17-18-131	97.67	3.67	877.48	52.67	28.47	36.94	58.56	3.88	1.43	2.50	2.61	13.66
S.Em±	0.82	0.26	8.48	0.92	0.65	1.16	1.91	0.29	0.19	0.18	0.12	1.08
C.D. 5%	2.45	0.79	25.43	2.76	1.94	3.47	5.72	0.86	0.58	0.55	0.36	3.24
C.V. %	1.60	9.13	2.33	4.02	6.95	8.20	7.69	11.24	11.34	10.31	7.81	10.57

Table 2: Data on the mean performance and yield potential of *leaf* Amaranthus in the *Rabi* season of the year 2018-19 under dryland condition.

Genotypes	LAI	No. of branches	No. of leaves	Total fresh wt. of plant (g)	Fresh wt. of leaf per plant (g)	Fresh wt. of stem per plant (g)	Leaf stem ratio	Chlorophyll content (SPAD)	Days taken to first leaf cutting	Leaf yield (kg/plot)	Leaf yield (q/ha.)
RENUSHREE KERALA AMA 17-18-101	4.35	3.27	31.47	52.64	9.27	21.76	0.42	34.32	34.00	5.37	134.25
CO-1 KERALA AMA 17-18-102	3.88	3.53	37.33	103.44	13.19	45.13	0.29	41.69	35.33	10.13	253.25
ANUSHREE AMA 17-18-105	3.56	3.47	32.33	87.48	10.26	41.34	0.24	37.51	34.00	8.32	208.00
HOSHANGABAD AMA 17-18-123	2.27	2.53	28.77	40.03	5.15	15.52	0.33	32.87	32.33	3.77	94.25
CHINDWARA AMA 17-18-124	2.36	2.40	32.47	45.69	5.76	18.16	0.31	31.41	36.00	4.44	111.00
CHINDWARA AMA 17-18-125	2.26	5.87	46.23	47.27	5.99	19.07	0.31	29.23	31.00	4.65	116.25
NAGPUR AMA 17-18-129	2.52	2.20	26.13	42.15	4.75	15.15	0.31	31.60	33.67	4.19	104.75
INDORE AMA 17-18-130	3.72	3.07	31.77	77.06	9.54	32.23	0.29	38.13	36.67	7.52	188.00
INDORE AMA 17-18-131	2.51	6.73	49.47	52.34	6.27	20.54	0.30	27.60	32.67	5.13	128.25
S.Em±	0.09	0.09	1.76	1.69	0.32	0.94	0.01	1.01	0.42	0.47	11.64
C.D. 5%	0.28	0.26	5.26	5.07	0.96	2.81	0.03	3.01	1.27	1.40	34.89
C.V. %	5.37	4.09	8.66	4.81	7.11	6.38	6.41	5.15	2.16	13.56	13.56

Genotypes	Germination %	Days taken for germination	Vigour Index-1	Vigour Index-2	Plant height 30DAS (cm)	Plant height 40DAS (cm)	Plant height 70DAS (cm)	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	Stem diameter (cm)	Leaf area (cm ²)
RENUSHREE KERALA AMA 17-18-101	83.33	9.33	715.48	40.98	24.81	35.55	62.44	8.25	5.33	5.20	2.96	32.27
CO-1 KERALA AMA 17-18-102	80.00	8.33	729.57	46.45	26.68	39.45	66.46	7.66	4.98	4.82	4.23	33.46
ANUSHREE AMA 17-18-105	82.67	8.00	746.48	43.25	23.62	33.43	58.25	6.44	4.23	4.67	3.86	29.47
HOSHANGABAD AMA 17-18-123	82.33	7.00	696.40	33.12	18.82	28.45	47.29	4.75	3.27	3.67	2.37	17.72
CHINDWARA AMA 17-18-124	89.00	6.67	671.83	37.31	18.65	31.60	59.49	5.13	3.75	3.96	2.59	20.22
CHINDWARA AMA 17-18-125	93.00	7.00	845.48	56.24	26.49	38.52	71.51	4.14	2.07	3.11	3.03	17.57
NAGPUR AMA 17-18-129	81.67	7.00	677.49	34.02	21.53	31.40	55.38	4.76	3.27	3.55	2.57	18.41
INDORE AMA 17-18-130	89.67	7.67	736.57	42.19	22.74	31.56	55.37	6.17	4.14	4.49	3.77	26.66
INDORE AMA 17-18-131	95.00	6.67	926.55	64.43	30.50	45.30	77.68	4.16	2.43	3.56	3.01	18.70
S.Em±	1.02	0.20	8.13	0.82	0.95	1.36	1.89	0.37	0.34	0.26	0.10	1.15
C.D. 5%	3.04	0.60	24.36	2.46	2.84	4.09	5.66	1.10	1.01	0.79	0.29	3.44
C.V. %	2.04	4.61	1.88	3.21	6.90	6.74	5.31	11.16	15.61	11.14	5.29	8.29

Genotypes	LAI	No. of branches	No. of leaves	Total fresh wt. of plant (g)	Fresh wt. of leaf per plant (g)	Fresh wt. of stem per plant (g)	Leaf stem ratio	Chlorophyll content (SPAD)	Days taken to first leaf cutting	Leaf yield (kg/plot)	Leaf yield (q/ha.)
RENUSHREE KERALA AMA 17-18-101	5.85	4.27	46.33	89.97	15.25	32.49	0.47	36.13	35.33	8.69	217.25
CO-1 KERALA AMA 17-18-102	5.48	6.60	59.57	160.68	22.13	67.76	0.32	42.43	31.00	15.56	389.00
ANUSHREE AMA 17-18-105	5.74	5.27	54.33	148.09	18.52	64.25	0.28	37.87	33.67	14.21	355.25
HOSHANGABAD AMA 17-18-123	3.38	3.40	41.27	71.64	9.64	29.56	0.32	32.49	30.67	7.26	181.50
CHINDWARA AMA 17-18-124	3.82	4.13	51.47	82.54	10.74	31.26	0.34	30.39	32.33	7.86	196.50
CHINDWARA AMA 17-18-125	3.32	8.40	67.83	85.33	10.09	37.19	0.27	29.75	33.33	8.58	214.50
NAGPUR AMA 17-18-129	3.44	3.97	47.07	75.44	10.49	31.60	0.33	31.52	28.33	7.03	175.75
INDORE AMA 17-18-130	5.37	4.27	55.47	136.78	18.74	57.23	0.32	39.47	33.00	12.97	324.25
INDORE AMA 17-18-131	3.47	9.20	70.83	91.58	11.38	40.25	0.28	29.23	32.00	8.97	224.25
S.Em±	0.10	0.18	2.13	1.99	0.48	1.27	0.02	0.96	0.56	0.47	11.72
C.D. 5%	0.31	0.53	6.38	5.98	1.43	3.82	0.06	2.87	1.69	1.41	35.13
C.V. %	4.08	5.54	6.71	3.30	5.87	5.07	9.99	4.82	3.03	8.02	8.02

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