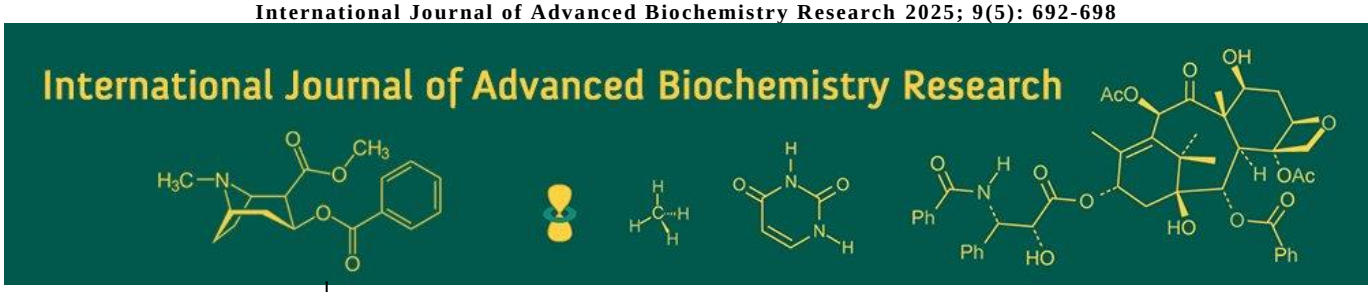

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Mean performance of grain Amaranthus genotypes under different seasonal conditions in Malwa region of Madhya Pradesh

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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 grain production. The present study material consisted of fifty-one indigenous *Amaranthus* spp. germplasm collections, including three released varieties and twenty accessions from the National Bureau of Plant Genetic Resources (NBPGR), New Delhi. Under 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.). These fertilizers were applied using urea, single superphosphate, and muriate of potash, respectively, for grain Amaranthus production in both seasons. 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. Observations were recorded on various yield and its related traits. In grain Amaranthus, overall, BETUL AMA 17-18-121 were among the best-performing genotype in terms of growth, vigour, and yield in both seasons.

Keywords: Seasonal variation, *Kharif*, *Rabi*, grain 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 Amaranthus 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) [3]. 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) [14]. 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 grain Amaranthus 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 fifty-one indigenous *Amaranthus spp*. germplasm collections, including three released varieties and twenty accessions from the National Bureau of Plant Genetic Resources (NBPGR), New Delhi. During the 2017-18 period, these accessions and germplasm were collected for grain Amaranthus production, specifically in the *Kharif* and *Rabi* seasons. Following this collection, 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, for grain Amaranthus production in both seasons. 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. Grain Amaranthus was harvested approximately 106 days after sowing in both seasons. 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 grain Amaranthus accessions under different seasonal conditions, providing insights into their adaptability and yield potential for grain production.

Results and Discussion

The data analysis of grain 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 and Table-2. During the *Kharif* season, germination percentages across genotypes ranged from 83.67% to 97.67%, with the highest germination rate was observed in INDORE AMA 17-18-131 (97.67%) and NBPGR Ah IC-333173 (97.67%) and the lowest in CO-1 KERALA AMA 17-18-102 (83.67%). During the *Rabi* season, germination percentages ranged from 80.00% to 97.33%, with the highest germination rate was recorded in NBPGR Ah IC-341551 (97.33%) and the lowest in CO-1 KERALA AMA 17-18-102 (80.00%). The higher germination percentage during the *Kharif* season might be due to the prevalence of favourable conditions and genotype's interaction with the environment. During the *Kharif* season, the days taken for germination varied from 3.00 to 6.67 days, with the fastest germinating genotypes included SERONJ AMA 17-18-103, MOORENA AMA 17-18-118, and others at 3.00 days, while RENUSHREE KERALA AMA 17-18-101 took the longest at 6.67 days. The vigour index 1 ranged from 538.25 to 996.54, with LOCAL COLLECTION AMA 17-18-104 recording the highest at 996.54, and NAGPUR AMA 17-18-129 the lowest at 538.25. The vigour index 2 ranged from 30.13 to 77.28, with DEWAS AMA 17-18-114 having the highest at 77.28, and HOSHANGABAD AMA 17-18-123 the lowest at 30.13. During the *Rabi* season, days taken for germination ranged from 5.00 to 9.33 days with BHIND AMA 17-18-110, NBPGR Ah IC-333108, NBPGR Ah IC-333211, and NBPGR Ah IC-258250 recorded the shortest germination time at 5.00 days, while RENUSHREE KERALA AMA 17-18-101 took the longest at 9.33 days. The long time taken for germination in some genotypes might be due to the presence of seed dormancy, while other genotypes with cream-colored seeds are free from this dormancy. The vigour index 1 ranged from 671.83 to 1027.47, with BETUL AMA 17-18-121 achieving the highest at 1027.47, and CHINDWARA AMA 17-18-124 the lowest at 671.83. The vigour index 2 ranged from 33.12 to 82.79, with LOCAL COLLECTION AMA 17-18-104 recording the highest at 82.79, and HOSHANGABAD AMA 17-18-123 the lowest at 33.12. The germination percentage is directly correlated with the vigour index.

During the *Kharif* and *Rabi* seasons, significant variations were observed in key plant traits across genotypes. In the *Kharif* season, plant height ranged from 9.18 cm to 43.40 cm at 30 DAS, 15.57 cm to 57.45 cm at 40 DAS and 32.69 cm to 110.71 cm at 70 DAS, with RATLAM AMA 17-18-115 and BETUL AMA 17-18-121 being the tallest. In the *Rabi* season, plant height ranged from 17.43 cm to 46.46 cm at 30 DAS, 28.45 cm to 66.46 cm at 40 DAS and 47.29 cm to 157.36 cm at 70 DAS, with SHIVPURI AMA 17-18-108 and BETUL AMA 17-18-121 being the tallest. BETUL AMA 17-18-121 also exhibited the highest plant weight, leaf length, and inflorescence length in both seasons. In the *Kharif* season, leaf width ranged from 1.29 cm to 5.90 cm with RATLAM AMA 17-18-115 recording the highest at 5.90 cm and CHINDWARA AMA 17-18-125 recording the lowest at 1.29 cm. In the *Rabi* season, leaf width ranged from 2.07 cm to 7.82 cm with BETUL AMA 17-18-121 recording the highest at 7.82 cm and CHINDWARA AMA 17-18-125 recording the lowest at 2.07 cm. DEWAS AMA 17-18-114 had the highest number of branches in both seasons. The earliest flowering occurred in NBPGR Ah IC-321281 in both seasons, while in the *Kharif* season the longest time to flowering and completion of flowering were recorded in CHINDWARA AMA 17-18-124, and in the *Rabi* season, the longest time to flowering and completion of flowering were recorded in RENUSHREE KERALA AMA 17-18-101. RENUSHREE KERALA AMA 17-18-101 also exhibited the longest time for inflorescence initiation in both seasons. The reproductive period ranged from 43.33 to 56.67 days in *Kharif* season and 48.00 to 61.67 days in *Rabi* season. The days to maturity varied from 98.00 to 122.67 days in *Kharif* season and 98.67 to 123.33 days in *Rabi* season.

Table 1: Data on the mean performance and yield potential of grain *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 30 DAS (cm)	Plant height 40 DAS (cm)	Plant height 70 DAS (cm)	Leaf length (cm)	Leaf width (cm)	No. of branches
1. RENUSHREE KERALA AMA 17-18-101	87.33	6.67	597.90	39.05	16.55	27.61	43.51	6.34	4.32	3.27
2. 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	3.53
3. SERONJ AMA 17-18-103	94.00	3.00	931.45	68.83	23.43	39.13	77.63	8.72	5.66	8.67
4. LOCAL COLLECTION AMA 17-18-104	94.67	3.67	996.54	74.90	24.44	37.59	74.57	7.93	4.79	8.20
5. ANUSHREE AMA 17-18-105	85.00	5.33	564.53	40.43	10.39	21.36	35.53	5 .73	3.88	3.47
6. JABALPU R AMA 17-18-106	95.33	4.00	876.67	58.20	31.40	40.44	68.34	6.86	4.21	7.13
7. BHIND AMA 17-18-107	93.00	5.33	909.43	55.08	30.43	42.65	71.34	6.17	3.55	6.67
8. SHIVPURI AMA 17-18-108	90.33	3.33	904.36	61.75	31.34	43.38	63.45	7.78	5.19	9.13
9. MORENA AMA 17-18-109	90.67	5.00	851.38	60.44	27.49	40.72	68.60	7.88	5.26	7.33
10. BHIND AMA 17-18-110	96.33	3.33	910.56	62.51	30.44	43.72	73.51	6.29	3.95	7.20
11. NEEMUCH AMA 17-18-111	94.00	5.00	859.65	56.44	32.55	40.89	66.36	7.36	4.66	6.27
12. MANDSAUR AMA 17-18-112	90.00	5.33	696.38	40.60	21.36	28.46	52.67	5.13	3.76	4.20
13. NEEMUCH AMA 17-18-113	92.33	4.00	918.67	68.27	24.36	35.92	70.48	7.53	4.99	8.93
14. DEWAS AMA 17-18-114	90.67	3.67	941.39	77.28	32.72	49.72	79.36	8.12	5.32	10.20
15. RATLAM AMA 17-18-115	95.00	5.00	926.53	64.39	43.40	57.45	107.46	8.76	5.90	9.27
16. GWALIOR AMA 17-18-116	91.33	4.00	675.60	43.54	10.14	22.32	47.37	5.72	3.37	4.53
17. SHVPURII AMA 17-18-117	93.33	3.67	856.82	53.42	22.42	35.46	56.60	6.13	3.94	6.20
18. MORENA AMA 17-18-118	94.00	3.00	820.68	47.39	20.71	32.85	59.31	5.76	3.42	6.13
19. SEHORE AMA 17-18-119	90.00	5.33	904.44	54.26	16.44	27.41	62.78	6.94	4.27	6.53
20. SEHORE AMA 17-18-120	93.67	4.67	710.36	49.73	18.40	29.56	53.71	6.08	3.84	4.27
21. BETUL AMA 17-18-121	94.00	4.33	989.57	72.57	37.43	55.42	110.71	8.89	5.67	9.73
22. CHINDWARA AMA 17-18-122	88.00	6.33	832.42	50.75	25.57	37.51	64.40	7.15	4.55	5.33
23. HOSHANGABAD AMA 17-18-123	85.67	5.67	544.45	30.13	12.57	18.42	38.47	3. 53	2.86	2.53
24.CHINDWARA AMA 17-18-124	88.33	4.67	555.74	31.79	18.39	21.94	42.40	3.27	2.49	2.40
25. CHINDWARA AMA 17-18-125	90.00	4.33	819.56	46.48	19.56	29.67	51.19	3.13	1.29	5.87
26. CHINDWARA AMA 17-18-126	91.67	3.67	920.37	66.85	35.39	52.49	96.44	7.0 8	4.34	6.93
27. BETUL AMA 17-18-127	92.00	5.00	910.63	65.13	23.50	38.37	68.37	8.31	5.52	8.97
28. BETUL AMA 17-18-128	93.33	4.33	907.69	60.73	22.35	33.70	66.76	6 .78	4.36	7.33
29. NAGPUR AMA 17-18-129	85.33	5.33	538.25	33.76	13.91	21.33	43.52	3 .58	2.66	2.20
30. INDORE AMA 17-18-130	94.00	4.67	595.50	38.30	13.69	20.34	33.68	4 .92	3.39	3.07
31. INDORE AMA 17-18-131	97.67	3.67	877.48	52.67	28.47	36.94	58.56	3 .88	1.43	6.73
32. NBPGR Ah IC-278919	96.00	3.33	650.64	45.49	13.43	19.55	38.58	4.41	2.76	4.73
33. NBPGR Ah IC-321281	97.33	3.00	649.66	40.11	12.44	19.31	36.65	3 .54	1.35	3.87
34. NBPGR Ah EC-223659	97.00	4.00	603.52	33.86	11.69	20.80	37.77	4.29	2.83	3.93
35. NBPGR Ah IC-278913	92.67	3.33	576.66	33.81	10.41	18.80	36.48	3.37	1.73	3.47
36. NBPGR Ah IC-333108	95.00	3.00	617.58	35.13	13.30	22.37	40.82	3.47	1.47	3.73
37. NBPGR Ah IC-322201	94.67	3.33	578.63	32.40	12.41	20.24	40.70	4.14	2.44	3.33
38. NBPGR Ah IC-333211	97.00	4.00	565.67	33.94	11.56	18.55	37.41	3.87	1.45	3.73
39. NBPGR Ah IC-329550	92.00	4.00	561.70	30.36	12.33	20.89	40.57	4.35	2.52	3.20
40. NBPGR Ah IC-313269	94.67	3.67	560.65	33.30	13.37	21.88	39.60	4.56	2.81	3.20
41. NBPGR Ah IC-278921	93.33	3.00	588.58	43.85	14.65	22.86	43.74	3.91	1.58	3.80
42. NBPGR Ah IC-279966	97.00	3.33	562.59	32.89	12.47	18.55	34.34	3.44	1.30	3.13
43. NBPGR Ah IC-329588	95.00	3.67	650.75	36.70	13.84	22.56	40.71	4.26	2.78	5.27
44. NBPGR Ah IC-333173	97.67	3.00	689.38	45.59	15.34	23.85	42.58	4.87	2.92	4.97
45. NBPGR Ah IC-341551	96.00	3.67	627.53	42.33	9.46	15.57	38.29	4.65	2.86	4.73
46. NBPGR Ah IC-278922	94.00	3.00	561.46	31.46	10.44	20.75	41.49	3.62	1.64	3.53
47. NBPGR Ah IC-274471	95.00	4.00	547.67	32.13	11.52	19.15	33.35	3.58	1.81	3.33
48. NBPGR Ah IC-258250	94.33	4.00	587.53	32.08	11.37	18.26	34.36	3 .64	1.41	3.53
49. NBPGR Ah IC-279968	92.00	3.33	554.81	39.21	9.25	18.59	38.93	3 .67	1.63	3.80
50. NBPGR Ah IC-279965	92.33	3.00	557.66	30.31	9.18	16.33	33.51	3 .51	1.67	3.53
51. NBPGR Ah IC-326896	93.67	3.67	552.71	32.47	9.36	16.69	32.69	3 .77	1.32	3.13
S.E.m±	0.94	0.25	10.04	0.94	1.02	1.55	2.33	0.32	0.25	0.26
C.D. 5%	2.62	0.71	28.16	2.63	2.86	4.36	6.53	0.88	0.70	0.73
C.V.%	1.75	10.71	2.41	3.47	9.28	9.26	7.59	10.08	13.14	8.59

Genotypes	Inflorescence length (cm)	Total plant weight (g)	Days taken to flowering	Days taken to complete flowering	Days taken for initiation of inflorescence	Reproductive period (Flowering to seed harvest)	Maturity duration (days)	Grain yield (g/plot)	Grain yield (q/ha.)	Test weight (g)	Protein content (%)
1. RENUSHREE KERALA AMA 17-18-101	6.76	52.64	69.33	79.00	60.33	53.33	122.67	35.96	0.89	0.87	12.47
2. CO-1 KERALA AMA 17-18-102	4.66	103.44	68.33	77.67	57.00	49.67	118.00	30.22	0.75	0.47	13.05
3. SERONJ AMA 17-18-103	26.32	137.35	53.00	61.33	45.67	53.00	106.00	290.46	7.26	0.74	15.67
4. LOCAL COLLECTION AMA 17-18-104	35.45	129.73	56.67	65.00	48.33	48.33	105.00	295.28	7.38	0.70	13.46
5. ANUSHREE AMA 17-18-105	5.44	87.48	68.00	78.33	58.67	49.33	117.33	33.60	0.84	0.78	12.68
6. JABALPU R AMA 17-18-106	20.76	95.62	51.33	59.00	44.67	52.67	104.00	167.82	4.19	0.55	15.71
7. BHIND AMA 17-18-107	27.14	110.21	54.67	64.33	45.33	48.33	103.00	199.21	4.98	0.59	15.42
8. SHIVPURI AMA 17-18-108	39.12	170.53	59.33	67.67	52.33	50.67	110.00	313.92	7.84	0.63	14.66
9. MORENA AMA 17-18-109	30.92	116.76	54.00	62.00	46.00	55.00	109.67	188.76	4.71	0.66	13.50
10. BHIND AMA 17-18-110	24.78	127.23	56.67	65.00	47.67	51.67	108.33	226.25	5.65	0.57	15.58
11. NEEMUCH AMA 17-18-111	21.20	107.34	57.67	66.67	50.00	51.33	109.00	145.68	3.64	0.60	15.04
12. MANDSAUR AMA 17-18-112	14.19	57.65	51.33	59.33	44.33	50.67	102.00	66.12	1.65	0.62	12.36
13. NEEMUCH AMA 17-18-113	33.68	140.46	56.00	65.00	48.00	49.00	105.00	254.60	6.36	0.73	16.43
14. DEWAS AMA 17-18-114	27.47	145.24	59.00	69.33	51.67	49.33	108.33	347.42	8.68	0.68	15.14
15. RATLAM AMA 17-18-115	35.33	170.13	58.33	67.67	49.00	51.00	109.33	366.94	9.17	0.76	14.28
16. GWALIOR AMA 17-18-116	19.14	59.57	54.33	62.33	47.00	46.67	101.00	101.45	2.53	0.58	13.22
17. SHVPURII AMA 17-18-117	16.88	116.54	53.33	63.00	46.00	55.67	109.00	144.78	3.61	0.72	13.86
18. MORENA AMA 17-18-118	19.62	92.44	53.00	61.00	44.67	56.67	109.67	156.14	3.90	0.66	14.55
19. SEHORE AMA 17-18-119	23.59	109.57	57.33	65.33	50.00	48.67	106.00	160.16	4.00	0.57	13.57
20. SEHORE AMA 17-18-120	14.79	83.34	55.33	64.33	46.67	45.33	103.33	82.62	2.06	0.68	16.13
21. BETUL AMA 17-18-121	39.52	173.72	59.33	68.67	51.00	50.67	110.00	426.84	10.67	0.67	14.16
22. CHINDWARA AMA 17-18-122	23.55	105.24	61.00	70.00	53.33	50.00	111.00	124.24	3.10	0.69	13.42
23. HOSHANGABAD AMA 17-18-123	3.29	40.03	67.67	75.00	57.67	47.67	115.33	22.53	0.56	0.72	12.83
24.CHINDWARA AMA 17-18-124	4.32	45.69	70.33	79.33	59.00	43.67	114.00	25.67	0.64	0.74	13.51
25. CHINDWARA AMA 17-18-125	3.38	47.27	64.33	73.00	55.67	51.00	115.33	128.92	3.22	0.82	12.32
26. CHINDWARA AMA 17-18-126	31.73	134.34	59.33	69.33	52.00	47.67	107.00	179.68	4.49	0.64	15.62
27. BETUL AMA 17-18-127	32.26	111.33	56.00	65.67	47.67	51.00	107.00	202.24	5.05	0.69	16.07
28. BETUL AMA 17-18-128	21.16	125.45	59.67	67.00	52.00	49.33	109.00	149.18	3.72	0.72	14.19
29. NAGPUR AMA 17-18-129	3.93	42.15	66.67	76.00	57.00	49.67	116.33	23.15	0.57	0.67	12.42
30. INDORE AMA 17-18-130	4.76	77.06	70.33	78.67	60.00	49.00	119.33	26.52	0.66	0.85	13.46
31. INDORE AMA 17-18-131	4.21	52.34	65.00	74.00	56.33	49.33	114.33	149.62	3.74	0.90	13.08
32. NBPGR Ah IC-278919	20.45	40.46	51.00	59.00	43.33	50.33	101.33	104.16	2.60	0.60	15.56
33. NBPGR Ah IC-321281	9.77	35.66	49.33	60.00	42.33	49.67	99.00	71.89	1.79	0.55	13.82
34. NBPGR Ah EC-223659	15.23	35.58	52.00	59.67	43.00	48.00	100.00	86.53	2.16	0.52	16.03
35. NBPGR Ah IC-278913	12.26	39.08	50.67	58.33	42.67	47.67	98.33	70.44	1.76	0.63	14.35
36. NBPGR Ah IC-333108	13.80	32.43	52.67	60.00	45.67	51.33	104.00	79.60	1.99	0.61	15.61
37. NBPGR Ah IC-322201	15.85	39.55	53.33	62.33	44.00	44.67	98.00	72.28	1.80	0.59	12.87
38. NBPGR Ah IC-333211	8.45	34.70	55.00	65.00	48.00	43.33	98.33	49.72	1.24	0.63	12.65
39. NBPGR Ah IC-329550	9.26	33.72	53.67	63.67	46.00	44.33	98.00	45.93	1.14	0.57	15.78
40. NBPGR Ah IC-313269	12.87	32.81	52.33	61.33	44.67	47.67	100.00	60.75	1.51	0.55	13.72
41. NBPGR Ah IC-278921	17.35	37.54	55.33	64.67	46.67	48.67	104.00	108.64	2.71	0.62	13.16
42. NBPGR Ah IC-279966	10.27	35.43	54.67	61.67	47.67	50.33	105.00	46.87	1.17	0.60	14.52
43. NBPGR Ah IC-329588	13.34	37.29	49.33	58.00	42.33	49.67	99.00	102.36	2.55	0.62	12.61
44. NBPGR Ah IC-333173	18.68	41.41	55.00	64.00	47.00	49.67	104.67	116.13	2.90	0.56	13.39
45. NBPGR Ah IC-341551	16.78	33.86	53.33	62.00	45.00	51.67	105.00	81.92	2.04	0.52	14.55
46. NBPGR Ah IC-278922	10.42	32.21	55.67	64.67	46.00	43.33	99.00	63.24	1.58	0.60	15.40
47. NBPGR Ah IC-274471	9.34	34.46	50.00	59.33	43.00	52.00	102.00	44.52	1.11	0.58	16.34
48. NBPGR Ah IC-258250	13.56	37.35	54.33	63.33	45.33	46.00	100.33	66.27	1.65	0.56	13.38
49. NBPGR Ah IC-279968	14.77	34.81	55.33	65.00	48.00	43.33	98.67	79.52	1.98	0.54	14.94
50. NBPGR Ah IC-279965	9.21	33.32	50.67	58.33	42.33	48.67	99.33	48.54	1.21	0.56	14.62
51. NBPGR Ah IC-326896	10.68	33.27	53.00	61.00	46.33	50.00	103.00	42.97	1.07	0.60	13.97
S.E.m±	1.13	2.06	0.65	0.80	0.58	0.86	0.52	3.24	0.08	0.01	0.13
C.D. 5%	3.18	5.79	1.81	2.24	1.63	2.42	1.45	9.10	0.23	0.04	0.37
C.V.%	11.35	4.69	1.97	2.10	2.07	3.03	0.84	4.40	4.40	3.47	1.63

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

Genotypes	Germination %	Days taken for germination	Vigour Index-1	Vigour Index-2	Plant height 30 DAS (cm)	Plant height 40 DAS (cm)	Plant height 70 DAS (cm)	Leaf length (cm)	Leaf width (cm)	No. of branches
1. RENUSHREE KERALA AMA 17-18-101	83.33	9.33	715.48	40.98	24.81	35.55	62.44	8.25	5.33	4.27
2. 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	6.60
3. SERONJ AMA 17-18-103	90.33	6.00	970.56	70.56	35.59	50.65	119.63	9.29	6.16	9.67
4. LOCAL COLLECTION AMA 17-18-104	95.00	5.33	995.60	82.79	34.30	55.57	126.86	10.08	6.23	11.47
5. ANUSHREE AMA 17-18-105	82.67	8.00	746.48	43.25	23.62	33.43	58.25	6.44	4.23	5.27
6. JABALPU R AMA 17-18-106	91.67	6.00	928.41	66.63	34.47	43.60	100.43	8.85	5.73	10.67
7. BHIND AMA 17-18-107	91.00	5.67	923.82	63.55	33.49	47.45	96.55	8.15	5.66	8.80
8. SHIVPURI AMA 17-18-108	92.33	6.33	987.43	76.52	46.46	66.46	157.36	9.66	6.69	11.73
9. MORENA AMA 17-18-109	94.00	7.00	952.34	72.87	35.50	50.62	110.23	9.18	6.37	10.20
10. BHIND AMA 17-18-110	93.00	5.00	967.51	64.86	37.38	47.45	110.39	7.54	5.14	9.13
11. NEEMUCH AMA 17-18-111	91.00	6.00	918.78	58.44	31.68	42.33	101.41	8.28	5.47	8.73
12. MANDSAUR AMA 17-18-112	92.67	6.67	756.23	46.74	29.52	39.77	87.76	7.34	4.58	6.40
13. NEEMUCH AMA 17-18-113	95.00	6.00	1001.36	69.66	32.42	46.53	121.37	8.65	5.84	11.27
14. DEWAS AMA 17-18-114	90.67	5.67	945.35	79.32	34.46	50.61	121.47	11.37	7.43	13.13
15. RATLAM AMA 17-18-115	92.00	7.00	1002.48	71.36	46.34	62.82	133.36	10.17	6.56	10.80
16. GWALIOR AMA 17-18-116	92.67	5.67	813.69	51.21	22.59	39.44	81.59	7.17	4.52	6.67
17. SHVPURII AMA 17-18-117	90.67	6.33	886.55	56.87	30.66	44.66	90.34	7.79	5.07	7.73
18. MORENA AMA 17-18-118	93.00	6.00	919.34	60.47	31.62	44.22	98.18	7.16	4.79	8.67
19. SEHORE AMA 17-18-119	93.67	6.67	921.61	61.83	28.50	46.84	107.29	8.53	5.29	8.97
20. SEHORE AMA 17-18-120	92.00	7.00	810.30	51.56	23.42	40.52	95.44	8.86	5.79	6.67
21. BETUL AMA 17-18-121	94.00	6.67	1027.47	75.50	43.51	65.51	143.34	12.17	7.82	12.53
22. CHINDWARA AMA 17-18-122	90.33	7.33	857.43	52.84	31.59	48.54	107.41	9.27	6.45	7.13
23. HOSHANGABAD AMA 17-18-123	82.33	7.00	696.40	33.12	18.82	28.45	47.29	4.75	3.27	3.40
24.CHINDWARA AMA 17-18-124	89.00	6.67	671.83	37.31	18.65	31.60	59.49	5.13	3.75	4.13
25. CHINDWARA AMA 17-18-125	93.00	7.00	845.48	56.24	26.49	38.52	71.51	4.14	2.07	8.40
26. CHINDWARA AMA 17-18-126	90.00	6.00	982.46	67.60	39.32	55.79	130.47	10.47	6.13	9.73
27. BETUL AMA 17-18-127	92.33	7.33	975.34	73.97	34.51	47.45	123.51	11.26	7.13	10.87
28. BETUL AMA 17-18-128	92.67	5.67	920.51	63.94	32.50	45.49	91.54	7.99	5.21	8.53
29. NAGPUR AMA 17-18-129	81.67	7.00	677.49	34.02	21.53	31.40	55.38	4.76	3.27	3.97
30. INDORE AMA 17-18-130	89.67	7.67	736.57	42.19	22.74	31.56	55.37	6.17	4.14	4.27
31. INDORE AMA 17-18-131	95.00	6.67	926.55	64.43	30.50	45.30	77.68	4.16	2.43	9.20
32. NBPGR Ah IC-278919	92.33	6.33	766.54	48.37	20.73	36.18	78.29	5.30	3.19	6.33
33. NBPGR Ah IC-321281	94.67	5.67	746.32	41.61	18.85	29.58	65.31	5.79	3.53	5.67
34. NBPGR Ah EC-223659	96.67	6.00	713.39	40.64	17.95	32.40	71.60	5.44	3.31	4.73
35. NBPGR Ah IC-278913	95.00	6.67	788.20	37.89	19.52	29.61	64.45	5.76	2.24	5.93
36. NBPGR Ah IC-333108	95.67	5.00	740.35	44.97	19.17	36.46	70.38	5.17	3.28	5.20
37. NBPGR Ah IC-322201	95.67	6.33	735.70	42.59	18.68	34.31	65.46	6.44	3.81	5.87
38. NBPGR Ah IC-333211	93.67	5.00	709.45	35.33	17.54	30.79	68.37	5.32	3.07	4.47
39. NBPGR Ah IC-329550	94.33	7.00	729.35	33.54	18.54	33.59	70.38	5.44	3.26	4.20
40. NBPGR Ah IC-313269	92.00	6.33	709.33	33.81	20.63	34.15	63.43	5.47	3.26	5.20
41. NBPGR Ah IC-278921	93.00	6.67	755.69	50.50	20.41	38.68	71.27	6.28	3.87	5.47
42. NBPGR Ah IC-279966	94.67	6.00	725.22	34.86	18.55	29.73	64.36	4.36	2.10	4.53
43. NBPGR Ah IC-329588	92.33	5.33	727.58	40.92	19.62	32.61	69.27	5.91	3.73	6.33
44. NBPGR Ah IC-333173	95.67	7.00	890.32	56.95	21.31	36.56	72.60	6.15	3.65	6.93
45. NBPGR Ah IC-341551	97.33	7.33	730.44	43.73	19.46	30.54	63.31	5.59	3.29	7.33
46. NBPGR Ah IC-278922	96.00	6.00	710.26	34.76	24.51	41.57	86.42	5.84	3.76	5.13
47. NBPGR Ah IC-274471	95.00	6.33	713.78	34.93	19.61	32.57	69.40	5.18	2.30	4.20
48. NBPGR Ah IC-258250	96.67	5.00	710.40	35.96	17.43	32.18	66.40	4.26	2.21	5.47
49. NBPGR Ah IC-279968	93.00	6.33	715.38	39.09	18.65	32.35	66.28	5.21	3.35	4.53
50. NBPGR Ah IC-279965	92.00	6.33	722.36	36.36	20.54	30.62	62.44	6.17	3.62	4.40
51. NBPGR Ah IC-326896	92.67	7.00	710.24	33.91	18.57	29.26	66.46	5.20	3.13	4.20
S.E.m±	0.99	0.28	11.85	0.96	1.19	1.65	2.73	0.57	0.33	0.30
C.D. 5%	2.78	0.77	33.26	2.69	3.33	4.62	7.66	1.60	0.94	0.83
C.V.%	1.86	7.40	2.50	3.21	7.73	7.06	5.50	13.93	12.96	7.19

Genotypes	Inflorescence length (cm)	Total plant weight (g)	Days taken to flowering	Days taken to complete flowering	Days taken for initiation of inflorescence	Reproductive period (Flowering to seed harvest)	Maturity duration (days)	Grain yield (g/plot)	Grain yield (q/ha.)	Test weight (g)	Protein content (%)
1. RENUSHREE KERALA AMA 17-18-101	13.08	89.97	66.67	75.67	57.67	56.67	123.33	108.42	2.71	0.94	12.54
2. CO-1 KERALA AMA 17-18-102	7.75	160.68	63.00	73.67	52.67	57.00	120.00	88.23	2.20	0.51	13.27
3. SERONJ AMA 17-18-103	47.87	209.34	48.33	56.33	40.33	58.67	107.00	712.90	17.82	0.82	15.64
4. LOCAL COLLECTION AMA 17-18-104	47.09	217.78	49.33	59.00	42.00	58.00	107.33	716.35	17.90	0.79	13.23
5. ANUSHREE AMA 17-18-105	11.54	148.09	64.67	73.33	55.00	53.00	117.67	128.19	3.20	0.89	12.84
6. JABALPU R AMA 17-18-106	34.91	178.74	47.00	55.00	40.67	56.67	103.67	612.27	15.30	0.75	15.52
7. BHIND AMA 17-18-107	38.77	206.57	51.67	61.00	42.00	52.33	104.00	580.04	14.50	0.76	15.34
8. SHIVPURI AMA 17-18-108	50.26	227.65	55.00	64.67	47.00	54.00	109.00	674.06	16.85	0.74	14.68
9. MORENA AMA 17-18-109	49.35	187.44	48.00	57.00	41.67	61.67	109.67	661.52	16.53	0.71	13.82
10. BHIND AMA 17-18-110	38.88	206.84	51.67	59.00	43.00	57.33	109.00	668.43	16.71	0.69	15.42
11. NEEMUCH AMA 17-18-111	34.12	182.26	55.33	63.33	46.33	54.33	109.67	563.14	14.07	0.80	15.15
12. MANDSAUR AMA 17-18-112	21.25	102.85	49.67	58.33	40.67	54.33	104.00	403.12	10.07	0.68	12.03
13. NEEMUCH AMA 17-18-113	49.86	228.48	52.00	62.67	43.67	51.67	103.67	726.99	18.17	0.87	16.57
14. DEWAS AMA 17-18-114	44.43	231.41	53.33	63.00	45.33	56.00	109.33	809.92	20.24	0.82	15.38
15. RATLAM AMA 17-18-115	52.44	238.72	52.33	60.00	44.00	56.67	109.00	733.09	18.32	0.85	14.22
16. GWALIOR AMA 17-18-116	28.16	101.67	47.67	56.33	40.67	54.00	101.67	457.16	11.42	0.70	13.06
17. SHVPURII AMA 17-18-117	26.74	162.71	50.67	58.67	43.33	58.67	109.33	519.83	12.99	0.83	13.87
18. MORENA AMA 17-18-118	37.23	171.77	49.00	58.00	41.33	59.00	108.00	496.06	12.40	0.81	14.34
19. SEHORE AMA 17-18-119	42.45	199.15	54.33	64.67	47.00	52.00	106.33	626.49	15.66	0.74	13.65
20. SEHORE AMA 17-18-120	24.72	151.64	50.00	59.33	41.67	53.67	103.67	429.18	10.72	0.81	16.26
21. BETUL AMA 17-18-121	56.53	246.76	53.00	62.00	44.33	57.00	110.00	901.13	22.52	0.77	14.33
22. CHINDWARA AMA 17-18-122	38.40	180.49	56.67	66.33	48.33	53.67	110.33	574.48	14.36	0.89	13.74
23. HOSHANGABAD AMA 17-18-123	6.19	71.64	63.00	73.00	54.33	52.67	115.67	65.86	1.64	0.85	12.68
24.CHINDWARA AMA 17-18-124	7.62	82.54	62.67	71.33	53.67	52.00	114.67	91.35	2.28	0.82	13.57
25. CHINDWARA AMA 17-18-125	4.77	85.33	60.33	69.67	51.00	54.00	114.33	483.26	12.08	0.90	12.37
26. CHINDWARA AMA 17-18-126	41.63	208.32	54.67	62.33	46.00	53.00	107.67	596.89	14.92	0.78	15.49
27. BETUL AMA 17-18-127	45.78	186.65	49.33	57.00	42.67	57.67	107.00	670.54	16.76	0.79	16.12
28. BETUL AMA 17-18-128	40.54	198.25	54.00	63.67	45.33	54.67	108.67	598.07	14.95	0.83	14.14
29. NAGPUR AMA 17-18-129	6.71	75.44	61.67	71.00	51.33	54.33	116.00	54.42	1.36	0.87	12.56
30. INDORE AMA 17-18-130	10.85	136.78	65.67	74.00	56.67	53.67	119.33	101.64	2.54	0.93	13.71
31. INDORE AMA 17-18-131	5.57	91.58	61.33	69.67	52.33	53.33	114.67	648.19	16.20	0.92	13.16
32. NBPGR Ah IC-278919	30.34	82.71	46.00	56.67	39.00	56.00	102.00	511.23	12.78	0.80	15.35
33. NBPGR Ah IC-321281	25.53	76.34	44.33	53.00	37.33	55.00	99.33	396.67	9.91	0.67	13.96
34. NBPGR Ah EC-223659	21.74	73.02	48.33	56.33	40.00	51.67	100.00	349.28	8.73	0.65	16.23
35. NBPGR Ah IC-278913	24.07	81.43	45.00	54.67	38.00	54.00	99.00	380.03	9.50	0.72	14.37
36. NBPGR Ah IC-333108	24.56	85.88	47.67	57.33	40.67	55.33	103.00	416.48	10.41	0.77	15.84
37. NBPGR Ah IC-322201	21.70	86.75	48.00	57.00	41.67	50.67	98.67	383.02	9.57	0.65	12.76
38. NBPGR Ah IC-333211	20.48	82.07	51.33	60.00	44.33	49.00	100.33	245.65	6.14	0.73	12.66
39. NBPGR Ah IC-329550	18.89	73.67	49.67	57.33	42.00	50.00	99.67	274.60	6.86	0.70	15.71
40. NBPGR Ah IC-313269	18.06	80.35	46.33	55.00	39.33	54.67	101.00	343.36	8.58	0.74	13.86
41. NBPGR Ah IC-278921	30.46	81.20	49.00	58.67	41.67	54.33	103.33	434.55	10.86	0.71	12.97
42. NBPGR Ah IC-279966	17.13	82.39	51.67	61.67	43.33	53.00	104.67	265.43	6.63	0.68	14.52
43. NBPGR Ah IC-329588	20.50	83.12	46.33	56.33	38.67	52.67	99.00	388.07	9.70	0.66	12.23
44. NBPGR Ah IC-333173	31.64	87.48	50.67	60.33	42.00	54.67	105.33	562.75	14.06	0.72	13.67
45. NBPGR Ah IC-341551	21.97	75.73	51.67	61.00	43.33	52.00	103.67	452.87	11.32	0.68	14.74
46. NBPGR Ah IC-278922	20.56	70.98	48.33	56.33	41.67	52.00	100.33	362.97	9.07	0.78	15.43
47. NBPGR Ah IC-274471	21.53	76.14	45.00	55.00	37.67	56.00	101.00	310.82	7.77	0.65	16.32
48. NBPGR Ah IC-258250	18.91	71.23	47.33	56.00	39.33	52.33	99.67	326.78	8.16	0.71	13.55
49. NBPGR Ah IC-279968	25.27	82.28	52.00	60.00	44.00	48.00	100.00	367.09	9.17	0.73	14.86
50. NBPGR Ah IC-279965	19.45	78.94	45.33	53.67	38.33	53.33	98.67	294.98	7.37	0.67	14.45
51. NBPGR Ah IC-326896	17.47	72.77	50.33	59.33	43.00	53.00	103.33	247.34	6.18	0.70	13.91
S.E.m±	1.45	2.40	0.75	0.86	0.67	0.91	0.65	4.21	0.11	0.02	0.13
C.D. 5%	4.07	6.74	2.12	2.41	1.89	2.55	1.83	11.82	0.30	0.04	0.36
C.V.%	9.05	3.14	2.50	2.43	2.64	2.90	1.06	1.63	1.63	3.49	1.58

During the *Kharif* season, seed yield ranged from 22.53 g/plot and 0.56 q/ha to 426.84 g/plot and 10.67 q/ha, with BETUL AMA 17-18-121 (426.84 g/plot and 10.67 q/ha) recording the highest yield, and HOSHANGABAD AMA 17-18-123 (22.53 g/plot and 0.56 q/ha) the lowest. During the *Rabi* season, seed yield varied from 54.42 g/plot and 1.36 q/ha to 901.13 g/plot and 22.52 q/ha, with BETUL AMA 17-18-121 (901.13 g/plot and 22.52 q/ha) yielding the most, and NAGPUR AMA 17-18-129 (54.42 g/plot and 1.36 q/ha) the least. In the *Kharif* season, test weight ranged from 0.47 g to 0.90 g, with INDORE AMA 17-18-131 (0.90 g) showing the highest test weight, while CO-1 KERALA AMA 17-18-102 (0.47 g) recorded the lowest. In the *Rabi* season, test weight varied from 0.51 g to 0.94 g, with RENUSHREE KERALA AMA 17-18-101 (0.94 g) having the highest test weight, and CO-1 KERALA AMA 17-18-102 (0.51 g) the lowest. In the *Kharif* season, protein content ranged from 12.32% to 16.43%, with NEEMUCH AMA 17-18-113 (16.43%) having the highest, while CHINDWARA AMA 17-18-125 (12.32%) had the lowest. In the *Rabi* season, protein content varied from 12.03% to 16.57%, with NEEMUCH AMA 17-18-113 (16.57%) again recording the highest, and MANDSAUR AMA 17-18-112 (12.03%) the lowest. The Amaranthus genotypes are an excellent source of protein, particularly due to their high content of essential amino acids, especially lysine and methionine. The higher percentage of bran fraction in Amaranthus contributes to its elevated protein levels. It is

considered a complete protein, as it contains all nine essential amino acids. 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 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. The grain yield is a complex quantitative trait, considerably influenced by several factors. The grain yield is increased as the yield attributing traits like inflorescence length, number of branches and plant height increased. Plant height, days to maturity, days to flowering, and length of inflorescence were also recognized as key direct drivers of grain output investigations. This is in agreement with the findings of Kandel *et al.* (2021) [4]. The similar findings with growth parameters were also confirmed by Koppa *et al.* (1997) [6] for plant height and grain yield. Wu *et al.* (2000) [16] for plant height, maturity duration, thousand grain weight and grain yield. Schahbazian *et al.* (2006) [13] for grain yield and protein content of grains. Gimplinger *et al.* (2007) [1] for germination percentage, time from sowing to harvest, thousand seed weight and protein content of grains. Gimplinger *et al.* (2008) [2] for plant height. Rivelli *et al.* (2008) [12] for grain yield. Manikandan and Srimathi (2015) [9] and Mbwambo *et al.* (2015) [10] for grain yield over the two seasons. Lokeshkumar and Murthy (2017) [8] for grain yield. Panda *et al.* (2017) [11] for plant height, leaf length and leaf breadth. Kumar and Yassin (2018) [7] for grain yield and protein content. Tiwari *et al.* (2018) [15] for plant height and grain yield under rainfed condition. Yadav (2018) [17] for days to 50% flowering, maturity duration and thousand grain weight.

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