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Assessment of Genetic Variability for Nutrient Status in Grain and Leaves of Amaranthus Genotypes

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ABSTRACT

In the present investigation 18 different genotypes of amaranthus were analyzed for nutrient status and noticeable range of major nutrients were reported in leaves and grains. The phenotypic coefficient of variation and genotypic coefficient of variation was maximum for leaf color constituent *b** i.e., 63.76 and 63.76 while, minimum in case of leaf moisture i.e., 6.62 and 3.03, respectively. High heritability was observed for all the traits, maximum was recorded for leaf color constituent *b** (100%) and minimum was observed for leaf moisture (70.09%). High heritability (h^2 = 99.19%) with high genetic advance (GA=73.90%) as percentage of mean was observed for leaf vitamin C, which indicated that additive gene effects were more important for that trait. High genetic advance as per cent of mean was observed for leaf color constituent *b** (131.34) however, lowest for days to leaf moisture (5.23) which indicates the preponderance of additive genes and selection will be effective for improvement of these traits having high heritability with genetic advance as percent of mean.

Keywords *Amaranthus* spp., Nutrient status, Genetic advance, Heritability, PCV, GCV.

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INTRODUCTION

Amaranthus (*Amaranthus* spp. (L.)) belongs to the family Amaranthaceae and genus *Amaranthus*. The word "Amaranthus" has derived from Greek language which means "one that does not wither" or "never fading". The genus *Amaranthus* consists of a large number of species that differ in morphology, yield and also nutrient status. There are two chromosome groups in amaranthus, n=16 and n=17. The species with n=16 are *Amaranthus hypochondriacus* and *A. caudatus* and the species with n=17 are *Amaranthus tricolor, A. spinosus, A. viridis, A. cruentus* and *A. blitum*. Cultivated amaranthus includes at least eight species grown for multiple purposes viz., *Amaranthus caudatus* L., *A. cruentus* L. and *A. hypochondriacus* L. for grain purpose (Andini *et al.* 2020), *A. dubious* L., *A. blitum* L., *A. hybridus* and *A. tricolor* L. as leafy vegetable (Omondi *et al.* 2016). Whereas, *A.*

retroflexus L. (redroot pigweed), *A. albus* L. (tumble weed), *A. palmeri* S. Wats. (Palmer amaranth) and *A. spinosus* L. (spiny amaranth) are considered as weed species (Bayón 2022). Amaranthus being a C_4 plant exhibits higher photosynthetic activity and productivity than C_3 plants. Amaranthus exhibits broad genetic variability in plant type, number of inflorescences, seed color, earliness, plant height, seed and green matter yield, resistance to pest and diseases and adaptability to soil, climate, rainfall and day length (Hoang *et al*. 2020) that re worldwide known, along with these there exists a great variability in case of nutrient content of amaranthus grain and leaf. Amaranthus is a historically sustained nutritional crop which was disappeared for centuries but is now emerging again and showing great potential for food and nutritional security around the world (Ruth *et al.* 2021). As amaranthus can be used as both vegetable and grain crop and has the ability to be grown in varied climatic conditions, it is considered as a good source of nutritional security for a wide array of population (Ruth *et al.* 2021). In America (South America and Central America) where amaranth is thought to have originated (Stetter and Schmid 2017), the grain is the principal product harvested for human consumption. Amaranthus grain is relatively rich in protein (De-Souza *et al*. 2018) and the first recorded use of amaranthus grain as a staple food was by the Aztec civilization in the central Mexico (Aderibigbe *et al.* 2022), whereas amaranth leaves and stems are used as vegetables in South Asian and African countries (Jiménez-Aguilar and Grusak 2017). Ethiopian research on nutritional properties of raw amaranthus depicted that, raw amaranthus grain can contribute 50-102% of the daily requirements of the essential amino acids (histidine, isoleucine, lysine, threonine and valine) for 6-23 months old children (Sokolova *et al.* 2021). Leaves and branches of amaranthus are potential sources of calcium, iron, magnesium and vitamins A and C (Sarker and Oba 2019) and are good source of protein that is comparable with that of spinach.

Further, there is a need to intensify the development of dual-purpose cultivars with nutrient rich quality. To plan appropriate breeding program and to evolve high yielding cultivars with higher nutritive value, the plant breeders must possess adequate knowledge on nutrient status of the amaranthus grains and leaves and the variability existing. To develop such program there is a need to evaluate the available genotypes, hence the present study has been carried out with the objective of nutrient mapping and also assessment of genetic variability for those traits in amaranthus genotypes.

MATERIALS AND METHODS

The experiment was conducted Department of Vegetable Science, College of Horticulture, UHS, Bagalkot, Karnataka during *kharif* i.e., from November 2020 to March 2021. The experiment consisted of 18 amaranthus genotypes that were collected from KRCCH, Arabhavi, NBPGR New-Delhi and some local collections are as follows GA-1, GA-2, GA-3, AG-303, SUVARNA, HUB GA-1, HUB GA-3, HUB GA-4, HUB GA-5, HUB GA-6, HUB GA-7, HUB GA-8, HUB GA-9, HUB GA-10, HUB GA-12, HUB GA-17, HUB GA-20, and HUB GA-28. The experiment was laid out in a Randomized Block Design (RBD) with two replications. The grain and leaf samples for nutrient analysis were collected from randomly selected five plants from each genotype and assessed for vitamin C by titration method (Sadasivam and Theymoli 1987), leaf iron analyzed by adopting thioglycollic acid method (Piper 1966), leaf, stem and grain fiber estimated by crude fiber estimation method suggested by Association of Official Analytical Chemistry by using fibro stat apparatus, leaf moisture using moisture meter, leaf oxalates through direct colorimetric determination of oxalates' (Julio and James 1954), leaf and grain color by using Hunter colorimeter, grain protein by Lowry's method (Lowry *et al.* 1951) and grain carbohydrates by phenol-sulphuric acid method suggested by Sadasivam and Manickam (1992). Variability parameters were worked out as per method given by Burton and Devane (1953), heritability in broad sense and genetic advance as percent of mean was calculated according to the formula given Johnson *et al.* (1995).

RESULTS AND DISCUSSION

The evidence from Table 1, depicts the significant difference among the amaranthus genotypes for the different characters at 5% significance. The Tables

Table 1. Analysis of variance for leaf and grain quality traits in amaranthus genotypes.

Sl. No.	Character Degrees of freedom	Genotypes 17	Replication 1	Error 17	SEm±	CD @ 5%
A.	Leaf quality parameters					
1	Vitamin C (mg/100g)	205.79	11452.90**	46.74	4.83	14.42
2	Leaf fiber (%)	0.11	1.13**	0.071	0.19	0.56
3	Stem fiber (%)	0.101	1.38**	0.050	0.16	0.48
4	Leaf iron (mg/100g)	0.018	31.47**	0.12	0.25	0.76
5	Leaf moisture (%)	0.105	17.01**	2.99	1.22	3.65
6	Leaf oxalates (mg/100g)	23.52	4107.28**	468.67	2.09	6.25
7.	Leaf color (*L** values)	0.0075	38.74**	0.010	0.07	0.21
	Leaf color (*a** values)	0.001	13.68**	0.0003	0.01	0.04
	Leaf color (*b** values)	0.001	40.18**	0.0004	0.01	0.04
B	Grain quality parameters					
8	Grain carbohydrates (%)	1.51	19.54**	1.31	0.81	2.42
9	Grain fiber (%)	0.0017	1.59**	0.057	0.17	0.51
10	Grain protein (%)	0.12	2.53**	0.20	0.32	0.95
11	Grain color (*L** values)	0.00017	174.43**	0.0025	0.04	0.11
	Grain color (*a** values)	2.78	5.27**	0.00046	0.02	0.05
	Grain color (*b** values)	0.0025	63.01**	0.0016	0.03	0.09

** Significant at 5% probability, Rep Replication, CD: Critical difference, SEm: standard error of mean.

Table 2. Estimation of amaranthus genotypes for leaf quality parameters for the year 2020-21.

Genotypes	Leaf fiber (%)	Leaf iron (mg/100 g)	Leaf moisture (%)	Leaf oxalates (mg/100 g)	Vitamin C (mg/100 g)	Stem fiber (%)	Leaf color *L**	*a**	*b**
GA 1	7.70	17.04	90.94	178.83	164.93	10.60	39.55	6.81	14.12
GA 2	8.40	15.05	88.20	270.50	243.48	11.25	35.07	4.10	4.80
GA 3	9.30	16.57	87.13	180.00	313.02	12.25	33.96	2.08	5.00
AG 303	9.30	23.50	85.36	289.66	325.65	12.10	42.53	2.75	10.14
SUVARNA	7.85	18.77	87.27	180.96	107.82	10.90	31.76	4.84	3.45
HUB GA 1	8.10	13.59	90.26	191.95	124.58	11.10	28.88	10.32	1.80
HUB GA 3	7.00	16.07	86.00	199.00	229.86	10.00	38.93	5.26	11.47
HUB GA 4	8.65	25.79	86.77	177.80	131.90	11.15	37.94	2.15	10.00
HUB GA 5	7.80	27.00	83.66	190.66	157.96	10.30	37.82	4.73	11.92
HUB GA 6	7.35	17.12	85.52	258.80	181.98	10.35	32.29	4.17	4.06
HUB GA 7	9.10	22.26	89.93	160.80	129.61	12.10	33.26	3.76	7.00
HUB GA 8	7.90	21.50	93.61	259.58	254.57	10.40	31.24	8.65	1.00
HUB GA 9	8.20	19.91	88.34	171.30	170.46	11.65	35.50	5.00	4.32
HUB GA 10	9.40	15.75	83.54	295.45	372.55	12.41	43.73	4.41	14.11
HUB GA 12	7.80	14.76	87.15	281.95	250.15	10.30	39.29	4.25	12.13
HUB GA 17	7.00	22.67	84.90	235.30	250.65	9.50	30.26	10.21	1.11
HUB GA 20	8.15	18.22	90.79	209.46	207.27	11.20	38.42	0.77	7.17
HUB GA 28	7.60	15.82	82.86	219.93	157.31	10.70	30.14	4.14	3.02
Maximum	9.40	27.00	93.61	295.45	372.55	12.41	43.73	10.32	14.12
Minimum	7.00	13.59	82.86	160.80	107.82	9.5	28.88	0.77	1.00

2, 3 and Fig. 1. depicts the nutrient status of the leaf and grains of amaranthus for leaf vitamin C (107.82-372.55), leaf iron (13.59-27.00), leaf oxalate content (160.80-295.45), leaf moisture percent (82.86-93.61), leaf fiber (7-9.40), stem fiber (9.50-12.41), leaf color constituent *L** (28.88-43.73), *a** (-6.81-10.32) and *b** (-1.80-14.12), grain protein (12.45-16.40), grain carbohydrates (63.20-74.45), grain fiber (6.70-9.40), grain color constituents *L** (22.37-62.60), *a** (1.73-10.05) and *b** (3.56-28.64). The estimates of geno-

Table 3. Estimation of amaranthus genotypes for grain quality parameters for the year 2020-21.

Genotypes	Grain carbohydrates (%)	Grain fiber (%)	Grain protein (%)	Grain color *L**	*a**	*b**
GA 1	64.55	7.00	15.40	56.95	7.23	25.94
GA 2	68.56	9.40	16.10	57.05	7.06	25.00
GA 3	71.50	8.60	15.20	52.18	7.30	25.46
AG 303	72.20	8.95	15.65	61.05	7.06	27.84
SUVARNA	73.75	8.95	14.50	62.60	7.00	28.64
HUB GA 1	72.80	7.40	16.40	59.26	7.26	26.51
HUB GA 3	70.70	9.25	14.95	58.95	6.75	26.14
HUB GA 4	66.40	9.10	15.35	59.87	7.54	27.84
HUB GA 5	70.95	7.80	13.20	57.30	8.96	28.25
HUB GA 6	70.12	6.70	14.65	56.42	8.50	26.74
HUB GA 7	63.20	7.35	13.45	58.98	8.08	27.84
HUB GA 8	74.00	7.18	13.70	44.56	10.05	26.90
HUB GA 9	71.17	8.00	14.45	60.32	7.28	26.85
HUB GA 10	71.20	7.95	12.45	58.82	7.88	27.18
HUB GA 12	70.51	8.40	15.00	60.47	7.56	26.66
HUB GA 17	72.96	8.15	13.50	22.37	1.73	3.56
HUB GA 20	69.11	7.25	13.90	61.53	6.97	27.68
HUB GA 28	74.45	6.70	12.90	59.56	7.86	27.78
Maximum	74.45	9.40	16.40	62.60	10.05	28.64
Minimum	63.20	6.70	12.45	22.37	1.73	3.56

typic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) for the leaf and grain quality parameters of amaranthus genotypes are presented in Table 4 and Fig. 2. The magnitude of (PCV and GCV) were found high for leaf vitamin C content (36.17 and 36.02), leaf iron (20.96 and 20.87), leaf oxalates (20.66 and 20.62), leaf color constituent *a** (53.30 and 53.29), leaf color constituent *b** (63.76 and 63.76), grain color constituent *a** (22.13 and 22.13) and grain color constituent *b** (21.83 and 21.83). The moderate values of PCV and GCV was recorded for characters viz., leaf color constituent *L** (12.37 and 12.37), grain fibre content (11.34 and 10.94) and grain color constituent *L** (16.67 and 16.67). The lowest values of PCV and GCV are recorded for characters viz., fiber content of leaf (9.52 and 8.94) and stem (7.70 and 7.42) along with leaf moisture (3.62 and 3.03), grain carbohydrates (4.58 and 4.29) and protein (8.07 and 7.46). Similar results were reported by Stevanović *et al.* (2023), Sarker *et al*. (2022) and Chakrabarty *et al.* (2018) in amaranthus.

High heritability combined with high genetic advance over mean are presented in Table 4 and Fig. 2 and was noticed for the parameters leaf vitamin C (99.19 and 73.90), leaf iron (99.19 and 42.83), leaf oxalates (99.57 and 42.38), leaf color constituents *L** (99.95 and 25.47), *a** (99.99 and 109.78) and *b** (100 and 131.34), grain fiber (93.05 and 21.74), grain color constituents *L** (100 and 34.35), *a** (98.98 and 45.58) and b* (99.99 and 44.97) this proved that these

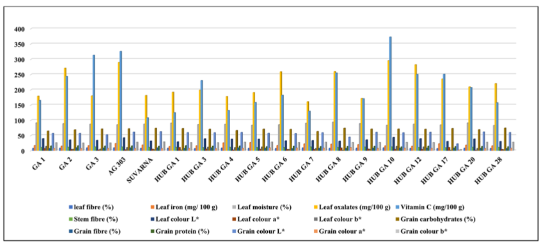

Fig. 1. Nutrient status of different amaranthus genotypes for their leaf and grain nutrients.

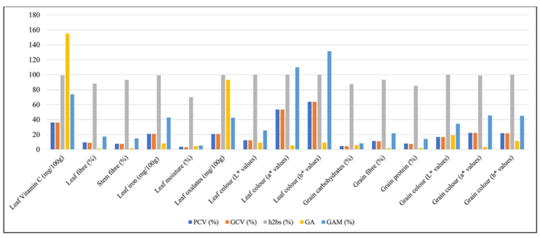

Fig. 2. PCV, GCV, Heritability, GA and GAM for leaf and grain quality traits of amaranthus.

Table 4. Estimates of genetic parameters for various leaf and grain quality traits in amaranthus genotypes.

Sl. No.	Trait	Range	Mean	GV	PV	PCV (%)	GCV (%)	h^2bs (%)	GA	GAM (%)
A Leaf quality parameters										
1	Leaf Vitamin C (mg/100g)	107.82-372.55	209.65	5703.08	5749.03	36.17	36.02	99.19	154.93	73.90
2	Leaf fiber (%)	7-9.40	8.14	0.53	0.60	9.52	8.94	88.10	1.41	17.28
3	Stem fiber (%)	9.50-12.41	11.01	0.67	0.72	7.70	7.42	92.91	1.62	14.73
4	Leaf iron (mg/100g)	13.59-27.00	18.96	15.67	15.80	20.96	20.87	99.19	8.12	42.83
5	Leaf moisture (%)	82.86-93.61	87.34	7.01	10.00	3.62	3.03	70.09	4.57	5.23
6	Leaf oxalates (mg/100g)	160.80-295.45	219.55	2049.26	2051.02	20.66	20.62	99.57	93.05	42.38
7	Leaf color (*L** values)	28.88-43.73	35.59	19.37	19.38	12.37	12.37	99.95	9.06	25.47
	Leaf color (*a** values)	-6.81-10.32	1.12	6.23	6.24	53.30	53.29	99.99	5.39	109.78
	Leaf color (*b** values)	-1.80-14.12	6.83	20.09	20.09	63.76	63.76	100	9.23	131.34
B Grain quality parameters										
8	Grain carbohydrates (%)	63.20-74.45	70.45	9.12	10.43	4.58	4.29	87.41	5.82	8.25
9	Grain fiber (%)	6.70-9.40	8.01	0.77	0.82	11.34	10.94	93.05	1.74	21.74
10	Grain protein (%)	12.45-16.40	14.49	1.17	1.37	8.07	7.46	85.24	2.05	14.18
11	Grain color (*L** values)	22.37-62.60	56.01	87.22	87.22	16.67	16.67	100	19.24	34.35
	Grain color (*a** values)	1.73-10.05	7.33	2.63	2.63	22.13	22.13	98.98	3.34	45.58
	Grain color (*b** values)	3.56-28.64	25.71	31.51	31.51	21.83	21.83	99.99	11.56	44.97

PV: Phenotypic variance
GV: Genotypic variance
PCV: Phenotypic coefficient of variation
GCV: Genotypic coefficient of variation
h^2bs: Heritability (broad sense)
GA: Genetic advance
GAM: Genetic advance as per cent over mean

traits have been controlled by additive gene action and also there is a scope of improvement of these traits in amaranthus through direct selection, Stevanović *et al.* (2023), Sheela *et al*. (2018) and Banupratap *et al. (*2018) were also of similar opinion on the quality traits of amaranthus crop.

CONCLUSION

Amaranthus being an underutilized crop is one of the major source of essential nutrients to the human diet. The traits like leaf vitamin C content, leaf iron, leaf oxalates, leaf color constituent *a**, leaf color constituent *b**, grain color constituent *a** and grain color constituent *b** that proved the respective magnitude of variability i.e., high. Meanwhile, leaf vitamin C, leaf iron, leaf oxalates, leaf color constituents *L**, a* and *b**, grain fiber, grain color constituents *L**, a* and *b** were found to be exhibited through additive gene action and found easy to improve through direct selection.

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