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Genetic variability studies in vegetable amaranthus

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Abstract
Genetic variability for various characters of *Amaranthus tricolor* (Vern. Thandukeerai) was assessed in germplasm collected across the tracts of north-east coastal region in the state of Tamil Nadu. A total of nine quantitative traits including plant height, number of leaves, leaf length, leaf breadth, leaf weight, stem weight, single plant weight, stem girth and biomass yield were recorded in these thirteen genotypes. Highest per plant foliage weight was recorded by AT3 (42.9 g) followed by AT6 (42.8). The stem of the cultures were either succulent or fibrous types. The phenotypic evaluation for overall evaluation identified seven cultures to be appealing as that of CO_5. The variance due to phenotypic and genotypic effects were studied and found that phenotypic variance was high compared to genotypic variance for all the characters in Amaranthus. The genotypes exhibited a high degree of variation for all the characters studied. The genotype mean sum of squares for most of the traits indicated the existence of variability among the collected genotypes. The magnitude of GCV and PCV were higher for the number of leaves, stem girth, plant height, stem weight and single plant yield.

Keywords: Amaranthus, thandukeerai, genetic variability, greens

Introduction
Amaranthus is being cultivated in Tamil Nadu and India. It is being considered as nutrition-packed healthy green vegetables and affordable to all sections (Ashok and Sakthivel, 2020) [2]. Among the most common greens in the state of Tamil Nadu, Thandukeerai (*Amaranthus tricolor, A. dubius*) are preferred for its delicious tender stem in addition to green leaves. Most of the varieties are suitable for uprooting in 25-30 days as Mulaikeerai and 40-45 days as Thandukeerai. Tamil Nadu Agricultural University released six varieties of Amaranthus for cultivation as Sirukeerai (*Amaranthus polygonoides*), Araikeerai (*A tristis*) and Thandukeerai (*Amaranthus tricolor, A. dubius*).
Amaranthus spp. is a major group of leafy vegetables being cultivated widely throughout India including Tamil Nadu. Due to its short duration, quick growth and regeneration potential, it is being preferred to grow throughout the year and fits well in any crop rotation model. The genus Amaranthus include 50-60 species, majority of which cultivated for leaf as well as for grains and few are wild species (Agadi *et al*, 2021) [1]. Vegetable type of leaf amaranth i.e., *A tricolor*, *A polygonoides*, *A tristis* are originated in south East Asia, particularly in India (Khader Mohideen and Subramanian, 1974; Rani and Veeraraghavathatham, 2003) [4, 6]. Plant hybridization, mutation and polyploidy breeding are the ways and means to restore or create the variability in the existing germplasm (Khader Mohideen and Subramanian, 1974) [4]. In order to document and assess the variability, survey, collection and evaluation of cultivated genotypes is the first step.
Studying the phenotypic expression of the plant characters and yield is controlled by the genetic makeup of the plant and environment which is composed of additive variance (Heritable) and non-additive variance including dominance and epistasis (Non-allelic) interaction (Agadi *et al*, 2021) [1]. In this direction, it becomes inevitable to elucidate the genetic variability parameters behind the observed phenotypic variation into its genotypic and phenotypic coefficient of variation. With this background, the present investigation was carried out to assess the extent of genetic variability in *Amaranthus* genotypes for yield and its component traits.

Material and Methods
In the present study, surveys were conducted during 2010-13 and various Amaranthus types were collected (Table 1) from across Tamil Nadu. A total of 58 thandukeerai / mulaikeerai types were collected from various districts of Tamil Nadu and Puducherry.

These collections were raised in the fields of Vegetable Research Station, Palur of Tamil Nadu Agricultural University to cull out the duplications, if any. The cultures were further purified and subjected to initial evaluation for morphological characters, yield and quality. The further evaluation for pest incidence and analysis were carried out 2018-19. The magnitude of genetic variability was performed following the standard procedures, phenotypic and genotypic coefficient of variation as suggested by Burton (1952) [3].

Results and Discussions

Collection and evaluation of Amaranthus (Thandukeerai) types

The collections were raised in the field for evaluation. Out of 58 accessions, 13 *A tricolor* genotypes were identified to be unique based on plant height, leaf morphology/colour, stem colour / thickness etc. Remaining's were identified to be merely duplications. During morphological evaluation, variation for leaf colour from light green to pink was observed. A majority of the genotypes possessed green leaves with green stem. The stem color among the genotypes includes pink, green, red and white. The stem of the cultures were either succulent or fibrous types. The phenotypic evaluation for overall evaluation identified seven cultures to be appealing as that of CO5. The present study identified culture AT6 with unique features such as white stem, petiole and green leaves with vigorous and robust root growth. This culture can better be exploited by directly releasing as a variety or to use indirectly as parent in breeding programme targeting genetic improvement of Amaranthus.

Mean performance of genotypes for various characters

Observations on qualitative and quantitative characters were recorded on randomly selected five plants on 50DAS for Amaranthus. The 13 cultures were raised in three replications in Randomized Block Design along with CO5 as check. The greens were harvested by uprooting and the yield was recorded. The extent of variation as explained by mean, range, phenotypic and genotypic coefficients of variation are furnished in Table 2 and Table 3. The plant height at harvest ranged from 21.2 (AT10) to 44.2 cm (AT11). Number of leaves per plant ranged from 12.8 to 34.2. The genotype AT10 exhibited longer and broader leaf and the short and narrow leaf length was observed in AT4. The maximum mean leaf length and width was observed in AT10 and was found to be 11.45 and 6.75 cm, respectively. The range was narrow for stem girth which stood at 4.2 – 5.6 cm. Highest per plant foliage weight was recorded by AT3 (42.9 g) followed by AT6 (42.8) with almost no difference among these genotypes. It was found that AT 6 (38.2 t/ha) followed by AT7 (35.0 t/ha) and AT8 (33.0 t/ha) exceeded the biomass yield of check CO5.

Variability among Amaranthus genotypes

Variation for the trait of interest and the presence of wide variability in the breeding materials is the basis for any crop improvement programme to increase the efficiency of selection. For any crop improvement programme, it is important and a pre–requisite to maintain the genetic variability that allows identification of promising genotypes in the germplasm collections that can be used in the breeding programme to develop promising cultivars. In the present study, the genotype mean sum of squares for most of the traits indicated the existence of variability among the collected genotypes. Existence of varying degree of variability for most of the quantitative traits in *Amaranthus spp*. has been reported by (Agadi *et al*. 2021) [1] and hence the variability of the collected genotypes can be best exploited in the breeding programmes targeting improvement of Amaranthus.

The variations underlying at phenotypic level is due to the combined effect of genotypic and environment. The variance due to phenotypic and genotypic effects were studied and found that phenotypic variance was high compared to genotypic variance for all the characters in Amaranthus. Similarly, the observations on the variability parameters revealed that PCV was higher than GCV for all the traits studied, indicating the additive nature of gene action. Similar results have been reported in Amaranthus (Nguyen *et al*. 2019) [5]. The magnitude of GCV and PCV were higher for total stem weight and leaf length. However, variation between PCV and GCV values was also observed for these characters, which indicates the influence of environment on trait expression. Being *Amaranthus tricolor* is used as leafy vegetable and as stem vegetable at later stages, theses vegetative characters are under the influence of environment. Hence, the findings that PCV is higher than GCV in this Amaranthus species is found to be appropriate. Further genetic dissection could be attempted in this species through characterisation using SSR markers or chloroplast based SSR markers and their utility in genetic improvement of vegetable amaranth could be demonstrated as reported by Nguyen *et al*. (2019) [5].

Table 1: Details of Amaranthus types collected from various parts of Tamil Nadu

Species	Vernacular name	Place/ District of collection	No. of genotypes collected
Amaranthus tricolor/ Amaranthus dubius	Mulaikeerai/ Thandukeerai	Thotti, Cuddalore	6
		Vilankalpattu, Cuddalore	6
		Kandalkadu, Cuddalore	5
		Theethampalayam, Cuddalore	5
		Ariyankuppam, Puducherry	6
		Pappireddipatti, Dharmapuri	6
		Attur, Salem	6
		Sevinipatti, Sivagangai	5
		Thoppupatti, Pudukottai	4
		Valappakudi, Thanjavur	3
		Kokkalantesi, Virudhunagar	6
		Total	58

Table 2: Comparative evaluation of select Amaranthus genotypes for their qualitative and quantitative characters

Genotype	Stem colour	Leaf colour	Stem succulence	PH (cm)	NL	LL (cm)	LB (cm)	SG (cm)	TLW (g)	TSW (g)	PPFW (g)	BY (t/ha)
AT1	Green	Green	Succulent	40.2	26.6	7.62	3.80	4.6	14.5	26.8	41.3	30.2
AT2	Red	Green	Fibrous	39.1	24.0	7.23	3.56	4.4	13.6	24.6	38.2	20.2
AT3	Green	Green	Fibrous	38.6	23.6	6.54	3.42	4.3	16.4	26.5	42.9	19.6
AT4	Green	Green	Succulent	22.4	18.8	4.81	3.12	4.3	17.8	19.7	37.5	30.0
AT5	Red	Red	Fibrous	39.0	24.6	5.42	3.86	4.4	13.2	23.5	36.7	29.6
AT6	White	Green	Succulent	41.4	28.8	6.69	3.48	4.8	12.4	30.4	42.8	38.2
AT7	Red	Green	Succulent	43.8	26.8	5.83	4.12	4.9	14.3	11.1	25.4	35.0
AT8	Green	Light Green	Succulent	39.6	34.2	5.12	4.56	4.4	15.8	24.5	40.3	33.0
AT9	Green with red stripes	Green	Fibrous	39.2	23.4	6.32	3.92	4.2	12.9	26.7	39.6	20.5
AT10	Dull red	Green	Succulent	21.2	12.8	11.45	6.75	4.8	10.6	9.1	19.7	22.5
AT11	Green	Green	Fibrous	44.2	28.0	7.13	4.56	4.9	14.8	22.9	37.7	32.6
AT12	Green	Light Green	Succulent	39.4	27.6	10.48	4.20	4.3	17.6	24.6	42.0	31.6
AT13	Pink	Pink	Succulent	42.1	28.4	5.15	4.23	5.6	11.5	20.5	32.0	29.6
CO5	Pink	Green	Fibrous	22.0	17.6	6.12	5.24	4.7	14.8	12.8	27.6	30.8
			Mean	36.59	24.66	6.85	4.20	4.61	14.29	21.69	35.98	28.81
			SED	0.83	1.36	0.32	0.15	1.73	0.54	1.04	1.32	0.94
			CD (0.05)	1.79	2.34	0.74	1.56	3.74	0.18	1.31	3.40	2.03
			CV	5.23	3.82	6.70	7.40	6.40	5.46	3.86	4.20	7.9

PH – Plant height @ 50 DAS, NL – No. of leaves, LL – Leaf length, LB – Leaf breadth, SG – Stem girth, TLW – Total leaf weight, TSW – Total stem weight, PPFW – Per plant foliage weight, BY – Biomass yield @ 50 DAS

Table 3: Estimates of genetic variability among select Amaranthus genotypes

Parameters	PH	NL	LL (cm)	LB (cm)	SG (cm)	TLW (g)	TSW (g)	PPFW (g)	BY (t/ha)
Mean	36.59	24.66	6.85	4.20	4.61	14.29	21.69	35.98	28.81
Minimum	21.2	12.8	4.81	3.12	4.2	10.6	9.1	19.7	19.6
Maximum	44.2	34.2	11.45	6.75	5.6	18.2	30.4	42.9	38.2
V ph	254.0950	2.1926	52.9145	0.3122	0.2721	15.7669	18.4982	286.7275	23.0256
Vg	247.1354	1.9469	50.8162	0.3034	0.2547	8.6719	13.9723	277.6366	19.7265
PCV	12.5065	13.4331	16.6390	11.4274	11.5579	6.2666	12.2561	20.4778	4.3170
GCV	12.3341	12.6580	16.3058	11.2655	11.1828	4.6475	10.6518	20.1505	3.9958

PH – Plant height @ 50 DAS, NL – No. of leaves, LL – Leaf length, LB – Leaf breadth, SG – Stem girth, TLW – Total leaf weight, TSW – Total stem weight, PPFW – Per plant foliage weight, BY – Biomass yield @ 50 DAS

Conclusion

The present study showed the existence of genetic diversity in Amaranthus (Thandukeerai) and all the characters studied showed variation. Deeper and wider explorative surveys are expected to result in effective identification and utilization of useful variation in this important species. Germplasm collection through systematic surveys and documentation is required to be taken up. Through the present study, one such example of identification of novel variant was characterized. In addition to the elucidation of genetic variability present among the cultivated Amaranthus species, a new, white stemmed Amaranthus culture (AT6) was identified to be high yielding among the other cultures/check. The culture may be studied further for its utility.

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