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# Genetic Basis of Yield and Quality Variations in Vegetable Amaranth (*A. tricolor*) to identify the Promising Genotypes

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**A B S T R A C T**

The present investigation was carried out to study the magnitude of genetic variability, correlation and path coefficient among 20 traits in ten amaranthus accessions belonging to *Amaranthus tricolor*. Comparison of genotypic co-efficient of variation (GCV) and phenotypic co-efficient variation (PCV) for different traits indicated that the values of PCV were higher as compared to GCV due to the influence of environment. High GCV and PCV were observed for leaf length, leaf breadth, stem weight, seed yield per plant and anthocyanin content. High estimates of heritability coupled with high genetic advance were recorded for plant height, number of leaves per plant, leaf length, leaf breadth, leaf weight, stem weight, green yield per plant, seed yield per plant, anthocyanin and nitrate content where heritability ranged from 80.21 to 97.62% and genetic advance from 30.51 to 57.15%, thereby these characters need to be given more importance in selection as these are expected to be controlled by additive genes. Significant and positive correlation of green yield per plant with plant height, stem girth, number of leaves per plant, number of branches per plant, leaf length, leaf breadth, ascorbic acid and crude fibre content was observed. Path analysis revealed that the number of branches per plant exerted the highest direct effect on green yield per plant and was indirectly influenced through days to flower appearance, stem girth, number of leaves per plant, leaf length and leaf breadth**.** It was concluded that green yield could be increased substantially in vegetable amaranthus through the indirect selection based on characters plant height, number of leaves per plant, leaf length, leaf breadth, green yield per plant, seed yield per plant, anthocyanin and nitrate content.

**Keywords**

Amaranthus,
Variability,
Heritability,
3Genetic advance,
Correlation,
Path coefficient.

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## Introduction

*Amaranthus* spp. are being cultivated since centuries for leafy vegetable (Grubben, 1976) as well as important food grain crop under varied agro climatic conditions ranging from tropical to temperate zones. *Amaranthus* has a high nutritional value because of the high levels of vitamins, including β- carotene (precursor of vitamin A), vitamin B6, vitamin C, riboflavin, and foliate, and dietary minerals including calcium, iron, magnesium, phosphorus, potassium, zinc, copper, and manganese (Sussan and Anne, 1988). This vegetable is also rich in lysine, an essential amino acid that is lacking in diets based on cereals and tubers (Schippers, 2000). Despite these nutritional benefits, the vegetable is known to bioacummulate various toxic substances and antinutrients such as oxlates, nitrates, alkaloids, phytate and cyanide.

Oxalate in combination with calcium leads to the formation of insoluble calcium oxalates which are precipitated and deposited in the kidney to form kidney stone (Prien, 1991).

High level of nitrates in vegetables when ingested can be converted to nitrite which can lead to cancer and metheamoglobinemia or blue-baby disease (Gupta *et al.*, 2000; Takebe and Yoneyame, 1997). Cyanide is a potent respiratory poison which exerts its ultimate lethal effect of histotoxic anoxia by binding to the active site of cytochrome oxidase, thereby stopping aerobic cell metabolism (Ames *et al.*, 1981; Ellenborn and Barcelonx, 1988).

To exploit the potentiality of *Amaranthus*, several genetic improvement techniques have been performed. Yield being the most important and polygenically controlled complex trait, is also governed by various physiological changes within the plant and influenced by many environmental factors in which the plant is grown, thus, it is not efficient character for selection.

The genetic association between yield and component traits and among themselves is important in predicting the correlated response to directional selection and in the detection of traits as useful markers. Therefore, the present study was undertaken to evaluate the variability in the collected leafy *Amaranthus* accessions, identify superior genotypes for homestead and commercial cultivation and to select different traits in crop improvement for increasing the foliage yield on the basis of association and path coefficient analysis.

## Materials and Methods

Ten accessions of *Amaranthus tricolor* (Table 1) were grown in Randomized Block Design with three replications with spacing of 25 cm x15 cm in a plot size of 2x2 $m^2$ during July, 2011 and February, 2012 at the College orchard, TNAU, Coimbatore. These accessions were obtained from different sources i.e. A-13, A-14, A-17, A-79 and A-161 were collected from Coimbatore; A-40 from Palur, A-59 from Namakkal, A-91 from Trichy; and A-151 and A-160 from M.S.S.R.F, Chennai. The observations for biometrical and quality traits were recorded on five randomly selected plants in each of the accession per replication and the data were statistically analyzed. The GCV and PCV was computed according to the Burton method (Burton, 1952), correlation analysis was carried out according to Goulden (1952) and path analysis was adopted to partition the genotype correlation coefficient into direct and indirect effects as suggested by Dewey and Lu (1959).

## Results and Discussion

In the present investigation, the differences between the phenotypic and genotypic coefficient of variations were observed to be narrow for all the characters indicating minimum influence of environment on the expression of these characters (Table 1 and Fig. 1). Higher estimates of respective genotypic and phenotypic coefficients of variation (Table 1) were observed for leaf length (27%, 27.92%), leaf breadth (26.60, 27.40), stem weight (20.84%, 22.22%), seed yield per plant (21.69%, 23.04%) and anthocyanin content (28.08%, 28.42%). Similar observations were made by Rana *et al.*, (2005) for leaf length and leaf width. Kamble (2000); Suryawanshi (2003) and Smitha and Krishnakumary (2011) recorded high GCV for grain yield per plant.

Moderate GCV and PCV for plant height (16.40%, 18.16%), petiole length (11.11%, 13.24%), stem girth (14.79%,16.55%), number of leaves per plant (17.12%, 19.11%), number of branches per plant (14.64%, 16.23%), leaf weight(16.72%, 18.20%), green yield per plant (17.43%, 18.93%), crude fibre content (13.49%, 14.29%) and nitrate content (17.67%, 18.36%) suggesting that the variability in these traits is due to the presence of genetic constitution. It must be recognized that the variability observed in some traits is primarily due to the differences in the genes carried by different individuals and the variability in other characters is due to the differences in the environment to which individuals have been exposed.

The knowledge of heritability of a character is important as it indicates the extent to which improvement is possible through selection (Robinson *et al.,* 1949). Heritability is the proportion of genotypic variance to the total variance i.e., phenotypic variance which is a measure of the genetic relationship between parent and progeny and has been widely used to assess the degree to which a character may be transmitted from parent to offspring thereby indicating the relative importance of heredity and environment in the expression of the characters (Burton, 1952). High value of heritability suggests that all the characters are under genotypic control. However, high heritability alone does not assure large gain from selection unless sufficient genetic gain is attributed to additive gene action. Genetic advance in a trait is the product of heritability and selection differential and has an added advantage over heritability as a guiding factor in a selection programme where characters to be improved are desired (Johnson *et al.*, 1955).

**Table.1** Genetic parameters for growth, yield and quality attributes

| Characters | GCV (%) | PCV (%) | Heritability (%) | GA as per cent of mean |
|---|---|---|---|---|
| Days to flower appearance (days) | 5.43 | 6.72 | 65.30 | 9.03 |
| Plant height (cm) | 16.40 | 18.16 | 81.55 | 30.51 |
| Petiole length (cm) | 11.11 | 13.24 | 70.37 | 19.20 |
| Stem girth (cm) | 14.79 | 16.55 | 79.96 | 27.25 |
| Number of leaves per plant | 17.12 | 19.11 | 80.21 | 31.58 |
| Number of branches per plant | 14.64 | 16.23 | 81.36 | 27.20 |
| Leaf length (cm) | 27.00 | 27.92 | 93.54 | 53.80 |
| Leaf breadth (cm) | 26.60 | 27.40 | 94.26 | 53.20 |
| Leaf weight (g) | 16.72 | 18.20 | 84.40 | 31.65 |
| Stem weight (g) | 20.84 | 22.22 | 87.97 | 40.27 |
| Leaf Stem ratio | 13.31 | 8.93 | 87.32 | 25.62 |
| Green yield per plant (g) | 17.43 | 18.93 | 84.83 | 33.07 |
| Seed yield per plant (g) | 21.69 | 23.04 | 88.61 | 42.06 |
| Ascorbic acid (mg/100g) | 10.98 | 11.83 | 86.21 | 21.00 |
| Carotene (mg/100g) | 7.34 | 8.23 | 79.56 | 13.48 |
| Protein (mg/100g) | 7.46 | 9.15 | 66.50 | 12.54 |
| Crude fibre (g/100g) | 13.49 | 14.29 | 89.12 | 26.24 |
| Anthocyanin (mg/100g) | 28.08 | 28.42 | 97.62 | 57.15 |
| Oxalate (%) | 6.92 | 7.90 | 76.82 | 12.50 |
| Iron (mg/100g) | 10.31 | 10.86 | 90.10 | 20.15 |
| Nitrate (mg/100g) | 17.67 | 18.36 | 92.68 | 35.05 |

**Table.2** Genotypic correlation coefficients of biometrical traits

| Characters | DFA | PH | PL | SG | NL | NB | LL | LB | GY |
|---|---|---|---|---|---|---|---|---|---|
| DFA | **1.000** | -0.087 | 0.226 | -0.200 | -0.128 | 0.118 | -0.708** | -0.810** | -0.337 |
| PH | | **1.000** | 0.409 | -0.679** | 0.523* | 0.273 | 0.395 | 0.116 | 0.564** |
| PL | | | **1.000** | -0.270 | 0.409 | 0.789** | 0.168 | 0.166 | -0.485* |
| SG | | | | **1.000** | 0.297 | -0.268 | 0.119 | 0.131 | 0.466* |
| NL | | | | | **1.000** | 0.709** | 0.221 | 0.327 | 0.939** |
| NB | | | | | | **1.000** | -0.051 | 0.011 | 0.714** |
| LL | | | | | | | **1.000** | 0.909** | 0.458* |
| LB | | | | | | | | **1.000** | 0.452* |

* Significant at 5 %
** Significant at 1 %
DFA – Days to flower appearance, PH– Plant height, PL– Petiole length, SG– Stem girth, NL –Number of leaves per plant, NB – Number of branches per plant, LL – Leaf length, LB – Leaf breadth, GY – Green yield per plant.

**Table.3** Genotypic correlation coefficients of qualitative characters

| Characters | AA | CA | PR | CF | ANT | OX | IR | NIT | GY |
|---|---|---|---|---|---|---|---|---|---|
| AA | **1.000** | -0.257 | -0.156 | 0.089 | 0.372 | -0.249 | -0.226 | 0.449* | 0.628** |
| CA | | **1.000** | -0.042 | -0.534* | -0.022 | -0.341 | -0.330 | 0.030 | -0.291 |
| PR | | | **1.000** | 0.272 | -0.122 | 0.090 | -0.165 | -0.681** | 0.303 |
| CF | | | | **1.000** | 0.220 | 0.025 | 0.539* | -0.394 | 0.519* |
| ANT | | | | | **1.000** | -0.594** | 0.184 | -0.247 | -0.459* |
| OX | | | | | | **1.000** | 0.235 | -0.210 | 0.030 |
| IR | | | | | | | **1.000** | -0.385 | -0.108 |
| NIT | | | | | | | | **1.000** | 0.090 |

* Significant at 5 %
** Significant at 1%
AA – Ascorbic acid, CA – Carotene, PR – Protein, CF – Crude fibre, ANT – Anthocyanin, OX – Oxalate, IR – Iron, NIT – Nitrate, GY – Green yield per plant.

**Table.4** Direct and indirect effects of biometrical traits on green yield

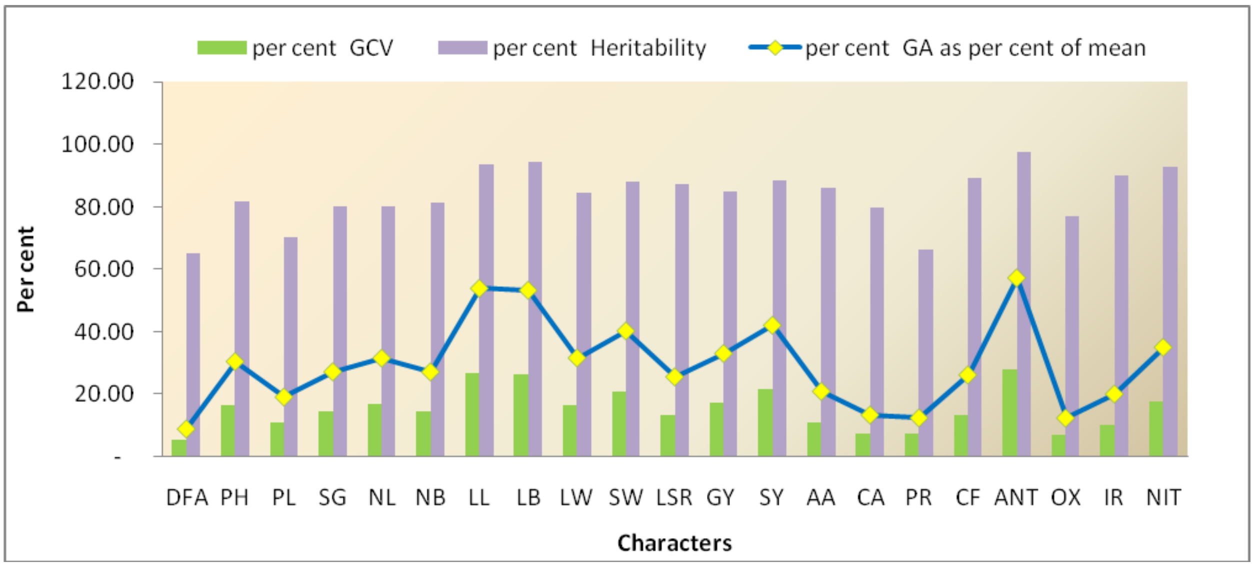
| Characters | DFA | PH | PL | SG | NL | NB | LL | LB | Correlation with green yield per plant |
|---|---|---|---|---|---|---|---|---|---|
| **DFA** | **0.393** | 0.030 | -0.228 | 0.007 | -0.058 | 0.206 | 0.008 | -0.750 | -0.337 |
| **PH** | -0.034 | **-0.348** | -0.413 | 0.003 | 0.010 | 0.477 | -0.005 | 0.108 | 0.564** |
| **PL** | 0.089 | -0.142 | **-1.012** | 0.010 | 0.187 | 1.376 | -0.002 | 0.153 | -0.485* |
| **SG** | -0.079 | 0.028 | 0.273 | **-0.037** | 0.135 | -0.468 | -0.001 | 0.122 | 0.466* |
| **NL** | -0.050 | -0.008 | -0.414 | -0.011 | **0.456** | 1.237 | -0.003 | 0.303 | 0.939** |
| **NB** | 0.046 | -0.095 | -0.798 | 0.010 | 0.323 | **1.745** | 0.001 | 0.010 | 0.714** |
| **LL** | -0.278 | -0.137 | -0.170 | -0.004 | 0.100 | -0.090 | **-0.012** | 0.841 | 0.458* |
| **LB** | -0.318 | -0.041 | -0.168 | -0.005 | 0.149 | 0.020 | -0.011 | **0.925** | 0.452* |

Bold letters indicate direct effects     Residual effect = 0.109

* Significant at 5 %, ** Significant at 1 %

DFA – Days to flower appearance, PH– Plant height, PL– Petiole length, SG– Stem girth, NL –Number of leaves per plant, NB – Number of branches per plant, LL – Leaf length, LB – Leaf breadth, GY – Green yield per plant

**Fig.1** Genetic parameters for growth, yield and quality traits




Days to flower appearance, PH– Plant height, PL– Petiole length, SG– Stem girth, NL –Number of leaves per plant, NB – Number of branches per plant, LL – Leaf length, LB – Leaf breadth, GY – Green yield per plant, SY-Seed yield, AA – Ascorbic acid, CA – Carotene, PR – Protein, CF – Crude fibre, ANT – Anthocyanin, OX – Oxalate, IR – Iron, NIT – Nitrate

High heritability coupled with high genetic advance (Table 1) was observed for plant height (81.55%, 30.51%), stem girth (79.96%, 27.25%), number of leaves per plant (80.21%, 31.58%), number of branches per plant (81.36%, 27.20%), leaf length (93.54%, 53.80%), leaf breadth (94.26%, 53.20), leaf weight (84.40%, 31.65%), stem weight (87.97%, 40.27%), leaf stem ratio (87.32%, 25.62%), green yield per plant (84.83%, 33.07%), seed yield per plant (88.61%, 42.06%), ascorbic acid (86.21%, 21%), crude fibre (89.12%, 26.24%), anthocyanin (97.62%, 57.15%), iron (90.10%, 20.15%) and nitrate content (92.68%, 35.05%) which implies that these traits are governed by additive gene action and consequently, substantial gain can be achieved through selection. The results are in conformity with the earlier findings of Ayiecho (1986) and Dutta *et al.,* (2002) for plant height; Revanappa and Madalgeri (1998) and Anuja and Mohideen (2007) for number of leaves per plant, leaf weight and stem weight; Varalakshmi and Reddy (1997) and Rani and Veeraragavathatham (2001) for green yield and Shukla *et al.,* (2006) for ascorbic acid content in *A. tricolor* accessions.

High heritability with moderate genetic advance were recorded for petiole length (70.37%, 19.20%), carotene (79.56%, 13.48%), protein (66.50%, 12.54%) and oxalate content (76.82%, 12.50%) whereas, high heritability with low genetic advance was observed for days to flower appearance (65.30%, 9.03%) which clearly shows the major role of non-additive gene action in the transmission of these characters from parents to offspring.

The genotypic correlation coefficients showed that among the sixteen characters studied for their correlation with foliage yield, only eight characters i.e. plant height (0.564), stem girth (0.466), number of leaves per plant (0.939), number of branches per plant (0.714), leaf length (0.458), leaf breadth (0.452), ascorbic acid (0.628) and crude fibre content (0.519) exhibited significant positive correlation, while other showed significant negative correlation and non-significant association with foliage yield (Tables 2 and 3). Significant association of green yield with leaf length and leaf breadth indicated that the larger leaves are more responsible for higher green yield due to high photosynthetic activity. Similar findings were also reported by Shukla *et al.,* (2009) where foliage yield showed significant positive association with plant height, fibre content and ascorbic content which indicated that selection based on these parameters would considerably enhance the foliage yield in *Amaranthus tricolor* accessions.

The interrelationship between the growth and yield attributes showed significant positive association of plant height with number of leaves per plant (0.523); petiole length with number of branches per plant (0.789); number of leaves per plant with number of branches per plant (0.709); and leaf length with leaf breadth (0.909). Shukla *et al.,* (2010) also reported positive and significant association of plant height with number of leaves per plant; and number of leaves per plant with number of branches per plant in vegetable amaranth.

The association between the quality attributes showed that ascorbic acid content exhibited positive and significant correlation with nitrate content (0.449); and crude fibre content with iron content (0.539) suggesting that all these traits may be considered for selection in breeding programme in order to increase and improve the green yield and its quality. Carotene content exhibited negative and significant association with crude fibre content (-0.534), protein content with nitrate content (-0.681) and anthocyanin content with oxalate content (-0.594) which suggests that these components may not contribute towards the improvement of yield and quality in *Amaranthus tricolor.*

The correlation coefficients were partitioned into direct and indirect effects to know the relative importance of the components (Table 4). Path analysis showed very high positive direct effect of number of branches per plant (1.745) followed by leaf breadth (0.925), number of leaves per plant (0.456) and days to flower appearance (0.393) on foliage yield per plant indicating that these traits could be a good selection criteria to improve the foliage yield. The character leaf length (-0.012) showed negative direct effect on foliage yield per plant which implies that leaf length may not be an effective selection criteria for yield improvement. However, the actual contribution of number of branches per plant on the foliage yield is influenced through days to flower appearance, stem girth, number of leaves per plant, leaf length and leaf breadth. The residual effect of 0.109 indicated the adequacy of the characters chosen for the study and the characters studied contributed about 89 per cent towards foliage yield per plant.

From the present findings, it is concluded that the phenotypic coefficient of variation was higher than the genotypic coefficient of variation for most of the traits indicating minimum influence of environment on the expression of these characters. High genotypic coefficient of variation with high heritability and genetic advance were observed for number of leaves and number of branches per plant followed by plant height, stem girth, leaf length and leaf breadth. Therefore, the above traits should be given more emphasis to achieve maximum gain through selection to realise the potential yield of *Amaranthus tricolor* with better nutritional attributes.

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