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GENETIC VARIABILITY STUDIES OF FRUIT MORPHOLOGICAL AND BIOCHEMICAL TRAITS IN CHILLI

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ABSTRACT

Chilli fruit exhibit a wide range of morphological and biochemical traits that contribute to their diverse appearance, flavours, and uses. Hence, quality in chilli is determined both by fruit morphological and biochemical traits. Variability for these quality traits is a prerequisite in chilli quality improvement through breeding.Variability among chilli genotypes was detected through analysis of variance (ANOVA) and descriptive statistics was used to summarize the variability. Distribution of variability across the chilli genotypes was visualised through frequency distribution histograms with expected normality. ANOVA of fruit morphological and biochemical traits revealed significant variation among chilli genotypes, thus substantiating the appropriateness of inclusion of 144 genotypes in capturing maximum variability for the investigated traits. Most traits, except fruit length, vitamin C and phenols, exhibited high genotypic variability. However, phenotypic variability was high for all the investigated traits. Except for vitamin C, heritability in broad sense was high for all studied traits. The genotype Byadgi Kaddi with high vitamin C (835.00 ppm), extractable color (140. 69 ASTA) and thin pericarp (0.87 mm) possessed the most desirable fruit quality traits. Bhutjalokia was identified as another genotype with both high vitamin C (508.62 ppm) and capsaicin (1762.29 µg/ml). Presence of this high genetic variability for quality traits plays a pivotal role in usage of these genotypes in breeding program.

Key words : Biochemical, Variability, ANOVA, Descriptive statistics, Histograms.

Introduction

Owing its origin to South and Central America, chilli has made its popularity across the world due to its ease of cultivation, often sharp taste and appealing look. Chilli is a dicot diploid angiosperm, scientifically grouped under the genus *Capsicum*, belonging to the family Solanaceae (Singh and Sharma, 2021). The *Capsicum* genus comprises around 30 different species (Antonio *et al.*, 2018 and Wahyuni, 2013) out of which, only five species, *i.e.*, *C. annum* L., *C. frutescens*, *C. chinense*, *C. baccatum* L. and *C. pubescens* have been cultivated after domestication (Wahyuni *et al.*, 2013).

Similar to any other crop, quality is one of the major considerations in improvement of chilli. Quality in chilli is essential for satisfying end users, safeguarding public health, complying with regulations and fostering sustainability of chilli products in the food industry. Chilli quality is determined by various parameters such as level of pungency, fruit color, fruit size and external texture, thickness of pericarp, vitamin C and phenolic content, whose consideration differs with different end users. In general, among quality determining traits of chilli, fruit morphological traits such as fruit length, fruit width, placenta length and pericarp thickness determines the external appearance of the fruit while, fruit biochemical traits such as vitamin C, capsaicin, phenols and extractable color decides bioactive, organoleptic, health promoting as well as industrial qualities of the fruit (Moon *et al.*, 2023; Dhall, 2008).

Fundamental requirement for any crop improvement program is the presence of genetic variation in a population. Variability observed in any population could be due to the genetic and environmental factors and also due to interaction between these factors. A critical estimate of nature and magnitude of this genetic variability is the prerequisite for crop breeding as the magnitude of genetic variability present in the germplasm is always proportional to its improvement. India being the secondary centre of origin of hot pepper, houses a large spectrum of variability for most of commercial characters (Thakur *et al*., 2018). Hence, the present investigation was carried out to estimate the extent of variability present in a set of chilli genotypes collected worldwide for fruit morphological and biochemical traits.

Materials and Methods

The material for the study consisted of 144 genotypes inclusive of germplasm collections, advanced breeding lines, working collections and wild relatives of cultivated chilli. Among 144 genotypes, 72 were procured from world vegetable centre (WVC), Taiwan and the remaining were obtained from chilli germplasm repository of Hot Pepper Improvement unit (HPI), Department of Genetics and Plant Breeding (GPB), University of Agricultural Sciences (UAS), Bangalore.

Genotypes were evaluated during summer 2021 and *kharif* 2022 in alpha lattice experimental design with two replications at the experimental plots of Department of GPB, K-block, UAS, GKVK, Bangalore. Out of fifteen plants maintained in each genotype and in each replication in both the years, randomly selected five plants were used to collect fresh green and red dry chilli fruits. Green fruits were used for fruit morphological traits as well as vitamin C estimation. Whereas, collected red fruits were shade dried to make a fine red chilli powder from around ten randomly selected dry fruits. Further dried red chilli powder of each genotype was used for the estimation of capsaicin, extractable color and phenols present in the fruit.

Estimation of fruit morphological traits

Genotypes were evaluated for fruit length (cm), fruit width (cm), placenta length (cm) and pericarp thickness (mm) in fresh green fruits collected from five randomly tagged plants.

Estimation of fruit biochemical traits

Estimation of vitamin C was performed by following the method given by Shara and Mussa (2019), which involves spectrophotometric determination of total ascorbic acid (ascorbic acid and dehydroascorbic acid) based on oxidation of ascorbic acid to dehydroascorbic acid by bromine water in presence of acetic acid. After coupling with 2,4-dinitrophenyl hydrazine at 37°C temperature for three hours, the solution was treated with 85% H_2SO_4 to produce a red color complex and the absorbance was spectrophotometrically measured at 521 nm.

Capsaicin content of fruits was estimated by colorimetric method as described by Bajaj *et al*. (1980). The phenolic group in capsaicin reduces phosphomolybdic acid to lower acids of molybdenum. The resulting component is blue in color and is read at 650 nm. The color intensity is directly proportional to the concentration of capsaicin.

The extractable color of chilli fruits measured in ASTA (American Spice Trade Association) units was determined using the procedure outlined by ASTA (1986). Solution of chilli powder dissolved in acetone was filtered using Whatman filter paper and final volume was made up to 100ml. Further, absorbance of final extract was read at 460nm using acetone as blank. ASTA color units were calculated as per the formula given below,

$$\text{ASTA} = \frac{\text{Absorbance at 460nm} \times 16.4}{\text{Weight of the sample in grams}}$$

Further, by employing Folin– Ciocalteu method, total phenolic content was measured from the dry red chilli powder spectrophotometrically, following the procedure outlined by Siddhuraju (2007). The reaction mixture containing 50% Folin- Ciocalteu reagent (0.5ml), 20% (w/v) sodium carbonate solution (2.5ml) and methanolic extracts of sample (1.0ml) was placed in the dark for 40 minutes and the absorbance was recorded at 765nm against a blank with the spectrophotometer.

Quantitative trait means of each accession, evaluated for fruit morphological and biochemical traits, across replications across years was used for analysis of variance (ANOVA). Further, descriptive statistics was used to summarize the variability. Genotypic coefficients of variance (GCV), phenotypic coefficients of variance (PCV) and heritability across quantitative traits were calculated employing the phenotypic and genotypic variances obtained from ANOVA. Distribution of variability across the panel was visualised through frequency distribution histograms with expected normality.

Results and Discussion

Results of ANOVA revealed significant differences among the genotypes for all investigated fruit quality traits (Table 1). Significance of mean sum of squares suggested

Table 1 : Analysis of variance for fruit morphological and biochemical traits among chilli genotypes across years (2021 and 2022).

Source of variation	Degrees of freedom	Mean sum of squares							
		Fruit length (cm)	Fruit width (cm)	Placenta length (cm)	Pericarp thickness (mm)	Vitamin C (ppm)	Capsaicin (µgm/ml)	Phenols (mg of GAE/ml)	Extractable color (ASTA)
Replication within years	02	0.59	0.03	2.98**	0.06	122	5830	0.05	1700
Blocks in replication within years	44	0.34	0.56**	0.42	0.01	119	1225	0.06*	1873**
Genotypes	143	32.55**	0.71**	23.66**	2.83**	31418**	301000**	3.42**	4246**
Years	01	3.31**	0.03	2.27*	0.06	603	3250	0.06	835
Genotype × year interaction	143	6.06**	0.14**	1.47**	0.21**	7590**	18908**	0.32**	1725**
Residuals	242	0.39	0.07	0.42	0.09	2408	4230	0.04	686

Significance at P = 0.05, ** significance at P = 0.01

Table 2 : Descriptive statistics for fruit morphological and biochemical traits among genotypes belonging to association panel in chilli.

Statistics		Fruit morphological traits				Fruit biochemical traits			
		Fruit length (cm)	Fruit width (cm)	Placenta length (cm)	Pericarp thickness (mm)	Vitamin C (ppm)	Capsaicin (µgm/ml)	Phenols (µgm/ml)	Extractable color (ASTA)
Average		8.94	1.31	5.77	1.38	328.32	890.42	3.23	66.01
Range	Highest	19.78	1.91	12.91	2.94	835.00	2075.84	3.80	226.19
	Lowest	3.65	1.12	0.72	0.66	111.60	382.72	2.06	36.41
Standardized range	Highest	2.21	1.46	2.23	2.13	2.54	2.33	1.17	3.43
	Lowest	0.41	0.85	0.12	0.48	0.34	0.42	0.64	0.55
Phenotypic coefficient of variation (%)		32.09	33.27	45.59	64.81	31.88	31.02	28.79	53.19
Genotypic coefficient of variation (%)		28.91	30.53	41.16	49.28	24.67	30.05	27.81	42.89
Heritability broadsense (%)		81.56	80.00	81.50	85.10	59.87	93.81	93.10	65.02

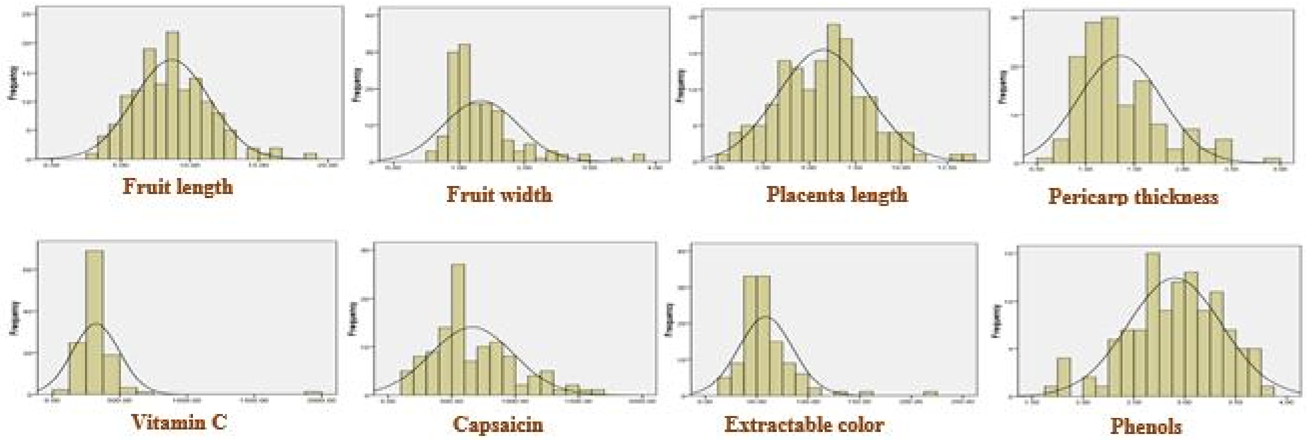

Fig. 1 : Frequency distribution of chilli genotypes for fruit morphological traits biochemical traits in pooled data across years.

the presence of considerable variability among the genotypes for all the fruit morphological and biochemical traits. In addition, significance of genotype × year interaction suggested that the genotypes responded differently to different years of evaluation for fruit quality traits, which demands the requirement for multi-environment testing to produce accurate and repeatable results.

Prevalence of adequate variability among the chilli genotypes for all the investigated traits was observed based on both first degree statistic (standardized range) and second degree statistic (coefficient of variances) (Table 2). Estimates of standardized range was highest for extractable color (3.43) while, phenotypic coefficient of variation (PCV) was highest for pericarp thickness (64.81%) and lowest (28.79%) for phenols. Compared to GCV, estimates of PCV were high for all the fruit quantitative traits. Wu *et al.* (2019), Lee *et al.* (2020) and Prasad (2022) observed similar extent of variability among a set of chilli genotypes. Genotypic variability, represented by GCV estimates, was also high for all the quantitative traits ranging from 24.67% (vitamin C) to 49.28% (pericarp thickness). Relatively lower GCV for vitamin C (24.67%), phenols (27.81%) and fruit length (28.91%) suggested that the genotypes varied moderately for these traits. Similar results were reported by Bundela *et al.* (2017), Sharma *et al.* (2019), Sran and Jindal (2019).

Genotypes with high capsaicin content, rich vitamin C levels, abundant phenolic compounds, unique colors, medium fruit length and width with thin pericarp are considered as desirable ones. Genotype byadgikaddi with high vitamin C (835.00 ppm), extractable color (140. 69 ASTA) and thin pericarp (0.87 mm) was considered as the most desirable one. Bhutjalokia is another genotype with both high vitamin C (508.62 ppm) and capsaicin contents (1762.29 µg/ ml). Comparable results were reported by Thilak and Pant (2017).

Conclusion

Chilli is one of the crops exhibiting maximum variability in most of the quantitative traits. ANOVA of fruit morphological and biochemical traits revealed significant variation among the chilli genotypes. Most traits, except fruit length, vitamin C and phenols, exhibited high genotypic variability. However, phenotypic variability was high for all the investigated traits. Presence of this high genetic variability in quality traits plays a pivotal role in usage of these genotypes in breeding program. The genotype Byadgi Kaddi with high vitamin C (835.00 ppm), extractable color (140. 69 ASTA) and thin pericarp (0.87 mm) possessed the most desirable fruit quality traits. Bhutjalokia was identified as another genotype with both high vitamin C (508.62 ppm) and capsaicin (1762.29 µg/ ml). Hence the genotypes identified with superior quality can be used as donor parents in future crop improvement programs.

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