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Assessment of genetic variability for biochemical traits in paprika (*Capsicum annum* L.) genotypes

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Abstract

An experiment was conducted to estimate the genetic variability, heritability and genetic advance for seven qualitative characters viz., ascorbic acid, oleoresin content, capsaicin content, total extractable colour, red carotenoids, yellow carotenoids and total carotenoids. Significant differences were observed among the genotypes for all the traits. The phenotypic coefficient of variation was higher than genotypic coefficient of variation for all characters. High magnitude of PCV and GCV were observed for all the traits indicating the existence of wide range of genetic variability in the germplasm for these traits. High heritability coupled with high genetic advance as % of mean was observed for all the characters indicating the predominance of additive gene action making the selection more effective.

Keywords: *Capsicum annum*, GCV, PCV, heritability, genetic advance

Introduction

Paprika (*Capsicum annum* L. $2n = 24$) is one of the most important commercial vegetable as well as spice crops grown all over the world. Paprika, a form of chilli is mainly valued for its high colour, low or no pungency and oleoresins. India is one of the leading chilli (*Capsicum annum* L.) producing countries of the world. Chilli has diverse utilities as a spice, condiment, and culinary supplement, and medicine, vegetable and ornamental plant. In view of the changing of food habits and health conscious, food quality particularly perishables like fruits and vegetables is gaining importance since improved quality not only facilitates remunerative market price for the producer and also improves health of the consumer. Thus, the attempts towards improvement of quality characters in crop plants have lot of significance which can increase the income of the farmer through premium price.

Chilli besides imparting pungency and red colour to dishes, is also rich source of vitamin C, A and E and assists in good digestion. The vitamin C content (150-200 mg/100g) of chilli is the highest among all the vegetables. Capsicinoids and carotenoids, the major chemical constituents of chilli fruits add commercial value to the crop. The carotenoids which contribute fruit colour act as dietary precursors of vitamin A and among carotenoids 'capsanthin, capsorubin and capsanthin 5, 6-epoxide are responsible for the final red colour. The nature of pungency has been established as a mixture of seven closely related alkyl vanillyl amides, collectively referred as "Capsaicinoids". Among capsiacinoids, capsaicin (8-methyl-N-vanillyl-6-enamide) and dihydrocapsaicin accounts for more than 80% and determine the pungency. The degree of pungency varies widely with the genotypes (Kumar *et al.*, 2006) [14]. The 'capsaicin' is an alkaloid present in the placenta of the fruit, which can directly scavenge various free radicals (Bhattacharya *et al.*, 2010) [15]. The pharmaceutical application of capsaicinoids is attributed to its antioxidant, anticancer, antiarthritic and analgesic properties (Prasad *et al.*, 2006) [20]. Chilli has also acquired a great importance because of the presence of 'oleoresin', which permits better color distribution and flavor in foods. There is considerable demand for paprika powder in the western countries. There is a great demand for the natural colour from paprika fruits and is used in processed foods in place of synthetic colours.

To improve the yield and other yield attributing characters, information on genetic variability present in the germplasm is pre-requisite. The improvement in any crop is proportional to the magnitude of its genetic variability present in germplasm. Greater the variability in a population, there will be the greater chance for effective selection for desirable types.

Heritability is the portion of phenotypic variation which is transmitted from parent to progeny. Higher the heritable variation, greater will be the possibility of fixing the characters by selection. Hence, heritability studies are of foremost importance to judge whether the observed variation for a particular character is due to genotype or due to environment. Heritability estimates may not provide clear predictability of the breeding value. Thus, estimation of heritability accompanied with genetic advance is generally more useful than heritability alone in prediction of the resultant effect for selecting the best individuals (Johnsen *et al.*, 1955) [11]. Therefore, a study was carried out to estimate the genetic variability, heritability and genetic advance in paprika germplasm in respect of qualitative traits.

Materials and Methods

The experiment was carried out with 44 genotypes of paprika at Horticultural Research Station, Lam, Guntur, and Andhra Pradesh, India. The site of the experiment at Lam is situated on 16.280 North latitude and 80.440 East longitude at an altitude of 31.5 m above mean sea level which falls under humid tropical climate. The soils of the experimental site are rich black cotton soils. A randomized block design with 44 treatments and two replications was used. The nursery was raised during first week of August and the seedlings were transplanted at a spacing of 75 cm × 30 cm in a row of 4 m length (experimental unit) during first fortnight of September. Each row consisted of 12 plants, of which five competitive plants were selected at random for collecting the fruit samples to estimate qualitative traits *viz.* Ascorbic acid (mg/100 g), oleoresin content (%), capsaicin content (%), total extractable colour (ASTA units), red carotenoids (%), yellow carotenoids (%) and total carotenoids (%).

Fruit samples were harvested at full ripe stage except for vitamin-C, for which mature green fruits were harvested. The red ripen fruits were sun dried for 6–7 days and ground in an electronic grinder and passed through a 0.5 mm sieve. By using chilli powder the following biochemical constituents were measured.

Ascorbic acid (mg/100 g)

Vitamin C content of mature green fruits was estimated by volumetric method described earlier (Sadasivam and Balasubramanian 1987) [25].

Oleoresin content (%)

The oleoresin content was estimated as per the standard procedure (Ranganna, 1986) [23]. Finely mashed 25 g chilli powder was transferred to a glass column, which was plugged by cotton plug on its narrow end. A thin layer of cotton was placed over chilli powder in the glass column and 25 ml of acetone was added. After all the acetone was decanted, 25 ml acetone was added each time till a total of 250 ml acetone was added to the contents. After decantation, the resulting red colored liquid in beaker contains all the principle constituents of chilli. The collected filtrate was transferred to a 250 ml volumetric flask and the volume was made up with acetone. The chilli extract was transferred to a 250 ml beaker of known weight (W1 g) and was kept in water bath at 50–60°C for 15–30 minutes so that acetone gets evaporated. Then, weight of the beaker along with contents was recorded as W2 g. The weight of the oleoresin content in the 25 g chilli powder was calculated and expressed in percentage using the given formula.

$$\text{Oleoresin content (\%)} = ((W_2 - W_1) \div \text{Weight of sample}) \times 100$$

Capsaicin content (%)

The capsaicin content of fruits was estimated by colorimetric method (Bajaj *et al.*, 1980) [4]; 0.5 g dry chilli powder was weighed into glass-stoppered test tube; 10 ml dry acetone (add 25 g anhydrous sodium sulfate to 500 ml of acetone at least one day before use) was added into the test tube and kept overnight for extraction. Next day samples were centrifuged at 10000 rpm for 10 min to get clear supernatant. 1 ml of the supernatant was taken in to a test tube and evaporated to dryness in a hot water bath. Then, the residue was dissolved in 5 ml of 0.4% of NaOH solution and 3 ml of 3% phosphomolybdic acid was added. The contents were shaken and left undisturbed for 1 h. After 1 hr, the solution was quickly filtered into centrifuge tubes to remove any floating debris, and then centrifuged at 5000 rpm for 15 min. The clear blue colored solution was directly transferred into the cuvette and absorbance was read at 650 nm along with a reagent blank. A standard graph was prepared using 0–200 µg pure capsaicin. Simultaneously 0.2, 0.4, 0.6, 0.8 and 1 ml of working standard solution (stock standard capsaicin solution was prepared by dissolving 50 mg capsaicin in 50 ml of 0.4% NaOH solution (1000 µg / ml) and working standard solution prepared by diluting the 10 ml of the stock standard to 50 ml with 0.4% NaOH solution (200 µg / ml) was taken into new test tubes and proceeded as mentioned above. Per cent capsaicin calculated using the formula mentioned below

$$\text{Capsaicin content (\%)} = (\mu\text{g capsaicin} \times 100 \times 100) \div (1000 \times 1000 \times 1 \times 0.5)$$

1% = 1, 60,000 SHU units

Total extractable colour (ASTA units)

Total extractable colour of fruits (ASTA–American Spice Trade Association units) was estimated as per the procedure given earlier (Rosebrook *et al.*, (1968) [24]. 100 mg of sieved fine chilli powder was weighed into a volumetric flask. Acetone was added and flask was closed tightly with stopper, then contents were kept for 16 h at room temperature in dark and shaken intermittently. Solution was filtered using Whatman filter paper and final volume was made up to 100 ml. Absorbance of final extract was read at 460 nm using acetone as blank. ASTA color units were calculated as per the formula given below,

$$\text{ASTA} = (\text{Absorbance at 460 nm} \times 16.4) \div (\text{Weight of sample in g})$$

Determination of yellow and red fractions in chilli powder

Total red (CR.; capsanthin, capsorubin and capsanthin-5, 6-epoxide) and yellow (CY. zeaxanthin, violaxanthin, antheraxanthin, β-cryptoxanthin, β-carotene and cucurbitaxanthin A) carotenoid isochromic fractions were estimated following protocol of spectrophotometric method (Hornero-Mendez and Minguez-Mosquera, 2001) [10]. Dried chilli fruits were ground into a fine powder and 100 mg of dried powder was extracted four times with 25 ml acetone until the complete exhaustion of the color. The extract was filtered and transferred to 50 ml volumetric flask and the volume was made up with acetone. The samples absorbance was read at two wavelengths i.e., 472 and 508 nm using acetone as blank. The red and yellow fractions were calculated using the following formulae.

$$CR (\mu\text{g/ml}) = ((A508 \times 2144.0) - (A472 \times 403.3)) \div 270.9$$

$$CY (\mu\text{g/ml}) = (A472 \times 1724.3) - A508 \times 2450.1) \div 270.9$$

$$\text{Total colour} = C^R + C^Y$$

$\mu\text{g/ml}$ values were converted into percentage on dry weight basis.

Analysis of variance was carried out as per the procedure given earlier (Panse and Sukhatme, 1985) [18]. The genotypic and phenotypic coefficients of variation were computed (Burton and Devane, 1953) [6] and categorized (Sivasubrahmanian and Menon, 1973) [27] while the heritability and genetic advance were calculated (Allard, 1960) [2] and categorized (Johnsen *et al.*, (1955) [11].

Results and Discussion

Analysis of variance revealed significant differences among the genotypes for all the traits indicating the presence of sufficient genetic variability in the genotypes (Table 1) and considerable scope for their improvement and the results are supported by similar reports of earlier workers Uma Jyothi *et al.*, (2008) [29], Arup *et al.*, (2011) [3], Naresh *et al.*, (2013) [17], Mahantesh *et al.*, (2013) [15], Mahantesh *et al.*, (2015) [16] and Janaki *et al.*, (2016) [12]. The extent of variability with respect to seven qualitative characters in different genotypes measured in terms of mean, range, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) along with the amount of heritability (h), expected genetic

advance and genetic advance as percent of mean (GAM) are presented in Table 2.

Table 1: Analysis of variance for qualitative characters in paprika (*Capsicum annum L.*). *: Significant at 5% level; **: Significant at 1% level

Character	Mean sum of squares		
	Replications Genotypes		
	Error		
Ascorbic acid (mg/100g)	145.89	4674.56**	151.61
Oleoresin content (%)	0.53	16.66**	0.66
Capsaicin content (SHU)	1784670.75	36198080.00**	157919.25
Total extractable colour (ASTA units)	22.99	2376.67**	115.58
Red carotenoids (%)	0.0005	0.02**	0.0007
Yellow carotenoids (%)	0.00004	0.015**	0.0009
Total carotenoids (%)	0.0003	0.03**	0.0019

The mean performance of genotypes (Table 2) for quality traits indicated that the high range of variability was recorded for capsaicin content (3002.50-20767.50) followed by ascorbic acid (26.78-207.30 mg/100g), total extractable colour (37.50-178.71 ASTA units) and oleoresin content (4.50-15.35%). Relatively low range of variability was observed in respect of yellow carotenoids (0.03-0.37%) preceded by red carotenoids (0.03-0.46%) and total carotenoids (0.12-0.72%). These findings are in accordance with earlier works Arup *et al.* (2011) [3], Uma Jyothi *et al.*, (2008) [29], Suryakumari *et al.*, (2010) [28], Naresh *et al.*, (2013) [17], Mahantesh *et al.*, (2015) [16] and Janaki *et al.*, (2016) [12].

Table 2: Estimates of mean, range, components of variance, heritability and genetic advance for qualitative characters in paprika (*Capsicum annum L.*)

Character	Mean	Range	GCV (%)	PCV (%)	h ² (b) (%)	GA @ 5%	GAM @ 5%
AA	93.14	26.78-207.30	51.05	52.74	93.72	94.84	101.81
OC	8.83	4.50-15.35	32.02	33.33	92.29	5.60	63.37
CC	9265.02	3002.50-20767.50	44.90	46.91	91.64	8204.21	88.55
TEC	109.44	37.50-178.71	30.72	32.26	90.72	65.97	60.28
RC	0.19	0.03-0.46	61.85	63.44	95.04	0.24	124.20
YC	0.20	0.03-0.37	42.60	45.21	88.77	0.17	82.68
TC	0.39	0.12-0.72	34.82	36.57	90.63	0.27	68.28

Where

AA-Ascorbic acid(mg/100mg), O- Oleoresin content (%), CC- Capsaicin content (SHU), TEV- Total extractable colour (ASTA units), RC- Red carotenoids (%), YC- Yellow carotenoids (%), TC- Total carotenoids (%), GCV-Genotypic coefficient of variation, PCV-Phenotypic coefficient of variation, h² (b)-Heritability at broad sense, GA-Genetic Advance, GAM-Genetic Advance as a per cent of mean.

The phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation for all the characters (Table 2) indicating the influence of environment on these characters and the considerable amount of variation was observed for all the characters. These observations are supported by earlier workers Arup *et al.*, (2011) [3], Farhad *et al.*, (2008) [8], Rajya lakshmi and Vijayapadma (2012) [22], Naresh *et al.*, (2013) [17], Mahantesh *et al.*, (2015) [16] and Janaki *et al.*, (2016) [12]. The estimates of PCV and GCV were high for all the traits indicating the existence of wide range of genetic variability in the germplasm for these traits. This also indicated broad genetic base, less environmental influence and these traits are under the control of additive genes and hence there is a good scope for the further improvement of these characters through simple selection. High heritability coupled with high genetic advance as % of mean was observed for all the characters indicating the predominance of

additive gene action and hence direct phenotypic selection is useful with respect to these traits. High PCV, GCV and high heritability coupled with high genetic advance as percent of mean have also been obtained earlier Farhad *et al.*, (2008) [8], Sharma *et al.*, (2010), Mahantesh *et al.*, (2013) [15], Patel *et al.*, (2015) [19], Janaki *et al.*, (2016) [12] and Priyanka and Naidu (2016) [21] for ascorbic acid; Singh *et al.*, (2009) [9], Kumari *et al.*, (2010) [28] and Vijaya *et al.*, (2014) [30] for oleoresin content: Kumari *et al.*, (2010) [28], Kumar *et al.*, (2012) [13], Datta and Das (2013) [7], Vijaya *et al.*, (2014) [30], Patel *et al.*, (2015) [19], Ajith and Manju (2015) [11] and Janaki *et al.*, (2016) [12] for capsaicin content; Gupta *et al.*, (2009) [9], Kumari *et al.*, (2010) [28], Naresh *et al.*, (2013) [17], Mahantesh *et al.*, (2013) [15], Patel *et al.*, (2015) [19] and Janaki *et al.*, (2016) [12] for total colour value; Naresh *et al.*, (2013) [17] and Janaki *et al.*, (2016) [12] for red and yellow: Naresh *et al.*, (2013) [17] for total carotenoids.

The findings indicate that there exists adequate genotypic variation in the genotypes for ascorbic acid, oleoresin content, capsaicin content, total extractable colour, red carotenoids, yellow carotenoids, total carotenoids showing high values of PCV, GCV and high heritability coupled with high genetic advance as % of mean suggesting predominance of additive gene action and lower influence of environmental factors in the expression of these traits with possibility for improvement through selection.

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