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Selection of promising genotypes for qualitative traits in paprika (*Capsicum annuum* L.)

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Abstract
Forty four genotypes of paprika (*Capsicum annuum* L.) were evaluated at Horticultural Research Station, Lam, Guntur (Andhra Pradesh), India; to select the promising genotypes for qualitative traits *viz.*, vitamin C, oleoresin content, capsaicin content, total extractable color, red carotenoids, yellow carotenoids and total carotenoids. The analysis of variance revealed significant differences among the genotypes for all the seven characters. Among forty four genotypes, the highest ascorbic acid content was recorded for the genotype LCA- 510 (207.30), while the lowest was observed in LCA- 443 (26.78). The highest oleoresin content was recorded by the genotype LCA-490 (15.35) and the lowest in LCA-482 (4.50). The highest capsaicin content was recorded by the genotype LCA-453 (20767.50), while the lowest was in LCA-482 (3002.50). The maximum color value was observed in the genotype LCA-499 (178.71) and the minimum in LCA-476 (37.50). The maximum per cent of red carotenoids was observed for genotypes LCA-510 (0.46) and the minimum in LCA-439 (0.03). The maximum per cent of yellow carotenoids was observed for the genotype LCA-436 and LCA-488 (0.37) and the minimum for LCA-425 (0.03).

Keywords: *Capsicum annuum*, ascorbic acid, capsaicin content, oleoresin content, total extractable color, red carotenoids, yellow carotenoids, total carotenoids

Introduction
Paprika (*Capsicum annuum* L. 2n = 24) is one of the 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 annuum* 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's, 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 color 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 color act as dietary precursors of vitamin A and among carotenoids 'capsanthin, capsorubin and capsanthin 5, 6-epoxide are responsible for the final red color. 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 (Bosland and Votava, 2000) [6]. The degree of pungency varies widely with the genotypes (Kumar *et al.*, 2006). The 'capsaicin' is an alkaloid present in the placenta of the fruit, which can directly scavenge various free radicals (Reddy and Lokesh, 1992; Kogure *et al.*, 2002; Bhattacharya *et al.*, 2010) [22, 13, 5] and has wide applications in the food, medicine and pharmaceutical industries.

Chilli has also acquired a great importance because of the presence of 'oleoresin', which permits better color distribution and flavor in foods. The demand for paprika oleoresin as a coloring agent has increased in international market especially in Europe and USA due to ban on artificial coloring substances (Joshi *et al.*, 1995) [12]. There is considerable demand for paprika powder in the western countries. There is a great demand for the natural color from

paprika fruits and is used in processed foods in place of synthetic colors. The fruits also contains flavonoids like quercetin, luteolin, apigenin, capsanthin, myristcin, hesperidin, scopoletin and phenolic compounds like esters of ferulic and sinapic acids, which have anti-oxidant activity and can scavenge various free radicles.

The availability of data on pungency and color are important criteria for selection of genotypes from a gene bank for use in crop improvement. However, data on pungency and carotenoids among the accessions in *Capsicum* gene banks are currently limited (Jarret *et al.,* 2003) [11]. Thus, the major objective of this study was to screen paprika genotypes for qualitative traits *viz.* ascorbic acid (vitamin C), capsaicin, oleoresin, total extractable color, red and yellow and total carotenoids.

Materials and Methods

The investigation was carried out during *kharif* 2016- 17 at Horticultural Research Station, Lam, and Guntur with 44 genotypes of paprika (*Capsicum annuum* L.) in a randomized block design with two replications. 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 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/100g), oleoresin content (%), capsaicin content (SHU), total extractable color (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 and ground in an electronic grinder and passed through a 0.5 mm sieve. By using chilli powder the following biochemical constituents were measured. Total extractable color of fruits (ASTA- American Spice Trade Association units) was estimated as per the procedure given by Rose brook *et al.* (1968) [23]. Total red (CR; capsanthin, capsorubin and capsanthin-5, 6-epoxide) and yellow (CY; zeaxanthin, violaxanthin, antheraxanthin, â-cryptoxanthin, â-carotene and cucurbitaxanthin A) carotenoid isochromic fractions were estimated following protocol of spectrophotometric method (Hornero-Mendez and Minguez-Mosquera, 2001) [9]. The capsaicin content was estimated by colorimetric method described by Balasubramanian *et al.* (1982) [3]. Ascorbic acid content of mature green fruits was estimated by volumetric (2, 6- dichlorophenol indophenol dye) method described by Sadasivam and Balasubramanian (1987) [24]. The oleoresin content was estimated as per the procedure given by Ranganna (1986) [21]. Analysis of variance was carried out as per the procedure given by Panse and Sukhatme (1985) [20].

Results and Discussion

The analysis of variance (table 1) revealed significant differences among the genotypes for all the seven characters studied indicating the presence of genetic variability in the genotypes and considerable scope for their improvement. These results are in conformity with findings of Farhad *et al.,* (2008) [7], Gupta *et al.,* (2009) [8], Suryakumari *et al.,* (2010) [28], Arup *et al.,* (2011) [1], Kumar *et al.,* (2012) [14], Naresh *et al.,* (2013) [19] and Janaki *et al*., (2015) [10].

Table 1: Analysis of variance for qualitative characters in paprika (*Capsicum annuum* 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 ascorbic acid content of fruits ranged from 26.78-207.30 mg/100g (table 2) with a mean of 93.14 mg/ 100g. The highest ascorbic acid content was recorded for the genotype LCA- 510 (207.30) followed by Byadagi kaddi (181.40 mg) while the lowest was observed in LCA- 443 (26.78) preceded by LCA 453 (32.92 mg). The range indicated that the variability in vitamin C content is higher between the genotypes studied. These results are in line with findings of Shirshat *et al.,* (2007) [25], Farhad *et al.,* (2008) [7], Arup *et al.,* (2011) [1], Kumar *et al.,* (2012) [14], Mahantesh *et al*., (2015) [16] and Janaki *et al.,* (2015) [10]. The oleoresin content ranged from 4.50% to 15.35% with a mean of 8.83 per cent (table 2). The highest oleoresin content was recorded by the genotype LCA 490 (15.35%) followed by LCA 465 (14.75%) while the lowest was observed in LCA 482 (4.50%) preceded by LCA 476 (4.60%) and LCA 475(4.90%). Manju and sreelathakumary (2002) [17], Singh *et al*., (2009) [27], Gupta *et al*., (2009) [8], Suryakumari *et al.,* (2010) [28], Arup *et al*., (2011) [1], Vijaya *et al*., (2014) [29] and Janaki *et al*., (2015) [10] also reported variability in respect of oleoresin content.

Table 2: Mean performance of various qualitative characters in paprika (*Capsicum annuum* L.) genotypes

Genotype	Source	Ascorbic acid (mg/100g)	Oleoresin content (%)	Capsaicin content (SHU)	Total extractable color (ASTA)	Red Caroteniods (%)	Yellow carotenoids (%)	Total Carotenoids (%)
LCA 445	HRS, Lam	48.60	5.50	7673.50	141.87	0.18	0.15	0.33
LCA 447	HRS, Lam	42.55	7.30	8772.00	72.85	0.18	0.26	0.44
LCA 439	HRS, Lam	112.86	5.00	14045.50	91.06	0.03	0.12	0.15
LCA 442	HRS, Lam	39.36	9.00	10550.50	97.72	0.22	0.07	0.30
LCA 430	HRS, Lam	83.97	6.25	9746.50	136.53	0.26	0.18	0.44
LCA 457	HRS, Lam	51.55	6.75	7911.50	98.10	0.11	0.12	0.23
LCA 443	HRS, Lam	26.78	11.00	17994.50	130.00	0.10	0.15	0.26

LCA 437	HRS, Lam	40.20	9.35	9762.50	145.40	0.05	0.30	0.36
LCA 453	HRS, Lam	32.92	5.45	20767.50	173.52	0.13	0.17	0.30
LCA 450	HRS, Lam	95.05	8.50	3406.50	115.00	0.44	0.27	0.72
LCA 441	HRS, Lam	66.60	11.70	11676.00	94.40	0.07	0.31	0.37
LCA 425	HRS, Lam	67.08	7.10	3072.00	151.11	0.11	0.03	0.15
LCA 440	HRS, Lam	64.74	8.70	19498.50	47.50	0.26	0.22	0.48
LCA 446	HRS, Lam	78.68	7.20	9203.50	163.68	0.08	0.12	0.21
LCA 470	HRS, Lam	41.73	7.60	5730.00	120.12	0.28	0.16	0.44
LCA 436-1	HRS, Lam	39.12	7.80	11044.00	160.00	0.17	0.37	0.54
LCA 466	HRS, Lam	171.95	8.05	11326.00	95.72	0.07	0.27	0.34
LCA 472	HRS, Lam	51.99	7.05	4624.00	147.68	0.18	0.16	0.34
LCA 476	HRS, Lam	179.75	4.60	9044.50	37.50	0.31	0.23	0.55
LCA 480	HRS, Lam	167.31	11.50	4552.00	61.81	0.06	0.13	0.19
LCA 482	HRS, Lam	150.15	4.50	3002.50	113.64	0.34	0.18	0.53
LCA 498	HRS, Lam	125.89	7.50	14739.50	93.69	0.36	0.14	0.50
LCA 465	HRS, Lam	83.61	14.75	5142.50	149.57	0.07	0.34	0.42
LCA 475	HRS, Lam	126.45	4.90	13628.00	61.11	0.07	0.13	0.20
LCA 488	HRS, Lam	60.74	7.60	6983.50	56.34	0.12	0.37	0.50
LCA 499	HRS, Lam	61.65	6.30	7431.50	178.71	0.33	0.27	0.60
LCA 506	HRS, Lam	39.70	10.05	6308.50	81.60	0.06	0.27	0.32
LCA 503	HRS, Lam	55.72	7.00	5898.50	136.40	0.33	0.08	0.41
LCA 490	HRS, Lam	60.44	15.35	7518.50	78.36	0.05	0.07	0.12
LCA 501	HRS, Lam	82.73	7.30	7568.00	93.90	0.06	0.26	0.33
LCA 504	HRS, Lam	86.26	8.45	13159.50	100.38	0.16	0.27	0.44
Genotype	**Source**	**Ascorbic acid (mg/100g)**	**Oleoresin content (%)**	**Capsaicin content (SHU)**	**Total extractable color (ASTA)**	**Red caroteniods (%)**	**Yellow carotenoids (%)**	**Total Carotenoids (%)**
LCA 510	HRS, Lam	207.30	7.90	16592.00	79.73	0.33	0.15	0.48
LCA 510-1	HRS, Lam	120.95	7.70	14343.00	67.75	0.46	0.10	0.56
LCA 511	HRS, Lam	73.39	9.00	8653.00	78.22	0.15	0.24	0.39
LCA 512	HRS, Lam	112.25	10.10	8660.50	118.14	0.36	0.25	0.62
LCA 513	HRS, Lam	124.96	9.10	7270.00	105.85	0.06	0.26	0.32
Warangal Chappatta single Patti	HRS, Lam	129.51	10.10	10431.50	98.28	0.14	0.26	0.40
Warangal Chappatta double Patti	HRS, Lam	72.93	14.55	5463.00	147.35	0.16	0.25	0.41
Byadagi Kaddi	HRS, Lam	181.40	11.35	6052.50	115.00	0.16	0.26	0.42
Byadagi Dabbi	HRS, Lam	138.30	6.70	6121.00	109.00	0.35	0.33	0.68
Kt-1	HRS, Lam	148.30	12.55	8779.50	141.04	0.27	0.13	0.41
Jangareddy Gudem local	HRS, Lam	174.26	14.25	5072.50	116.60	0.11	0.25	0.36
LCA-424	HRS, Lam	115.16	13.25	8872.50	111.43	0.33	0.05	0.39
LCA-436	HRS, Lam	63.54	12.92	9568.50	101.68	0.13	0.08	0.21
Mean		93.14	8.83	9265.02	109.44	0.19	0.20	0.39
C.V		13.22	9.25	13.57	9.82	14.13	15.15	11.19
F ratio		30.83	24.95	22.91	20.56	39.29	16.82	20.36
S.E.		8.71	0.58	888.80	7.60	0.02	0.02	0.03
C.D. 5%		24.83	1.65	2534.89	21.68	0.05	0.06	0.09

*Bold values indicate maximum and minimum mean performance

The capsaicin content ranged from 3002.50 SHU to 20767.50 SHU with a mean of 9265.02 SHU. The highest capsaicin content was recorded by the genotype LCA-453 (20767.50 SHU) followed by LCA-440(19498.50 SHU) and LCA-443 (17994.50 SHU) while the lowest was observed in LCA-482 (3002.50 SHU) preceded by LCA 425(3072.00 SHU) and LCA-450(3406.50 SHU). These findings suggest that it is possible to isolate superior genotypes during the selection process. Variability in capsaicin content of chilli accessions was earlier reported by Bharadwaj *et al.*, (2007) [4], Munshi *et al.*, (2010) [18], Shrilekha *et al.*, (2011) [26], Arup *et al.*, (2011) [1], Naresh *et al*., (2013) [19], Vijaya *et al*., (2014) [29] and Janaki *et al*., (2015) [10]. The total extractable color ranged from 37.50 to 178.71 with a mean of 109.44 ASTA units. The highest color value was recorded for the genotype LCA-499 (178.71) followed LCA-453 (173.52) and the lowest was observed by LCA-476 (37.50) preceded by LCA-440 (47.50). The range of red carotenoids (%) character varied from 0.03% to 0.46 % with a mean of 0.19 per cent. The maximum per cent was observed in genotypes LCA-510 (0.46%) followed by LCA 450 (0.44%) while the minimum was recorded in LCA 439 (0.03%) preceded by LCA 437 and LCA 490 (0.05%). The range of yellow carotenoids (%) character varied from 0.03% to 0.37% with a mean of 0.20 per cent. The maximum per cent was observed for the genotype LCA-488 and LCA-436 (0.37%) closely followed by LCA-465 (0.34%) and Byadagi dubbi (0.33%) while the minimum was observed in LCA-425(0.03%) preceded by LCA-424 (0.05%). The range of total carotenoids (%) character varied from 0.12% to 0.72% with a mean of 0.39 per cent. The maximum per cent was observed for the genotype LCA-450 (0.72%) closely followed by Byadagi dabbi (0.68%) and LCA-512 (0.62%) while the minimum per cent was recorded for LCA-490 (0.12%) preceded by LCA-439 and LCA-425 (0.15%).
These findings are in agreement with results of Naresh *et al.*, (2013) [19] and Janaki *et al*., (2015) [10], who also reported

higher variation among the genotypes for total carotenoids, red carotenoids and yellow carotenoids and also reported that red colored fruits contained both red and yellow carotenoids while yellow coloured fruits contained only yellow carotenoids.

Conclusion

In the investigation, a high range of variability was observed for all the characters. It was maximum for capsaicin content (3002.50-20767.50 SHU) followed by ascorbic acid content (26.78-207.30) and minimum for yellow carotenoids (0.03-0.37%). The characters showing wide range of variation provide an ample scope for selecting superior types and the selected genotypes can be used in breeding programme for introgression of their desired genes into the high yielding varieties.

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