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Association of biochemical constituents with anthracnose resistance in chilli

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ABSTRACT

Colletotrichum species is considered as amajor fungal pathogen that can cause economic damage in commercial chilli production because of its ability to infect fruits both at pre- and post-harvest stages. Results obtained from the Fourier transform near-infrared spectrophotometer in chilli genotypes indicated that, there is a significant difference among the chilli genotypes for both quantitative and qualitative traits. Furthermore, capsaicin and oleoresin contents have a significant linear relationship with resistance to anthracnose at red fruit stage. Incidentally, chilli genotypes that are moderately resistant to anthracnose were significantly superior in capsaicin and oleoresin contents and fruit yield. Hence, capsaicin and oleoresin content can be used as an indirect method to predict anthracnose resistance in chilli breeding.

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INTRODUCTION

Chilli (*Capsicum annuum* L.) belonging to family Solanaceae, is one of the important vegetable crops as well as most celebrated spice of every Indian household. The occurrence of pathogenic fungi, bacteria and viruses greatly hamper chilli productivity. Among them, anthracnose is considered as a major fungal pathogen, because of its ability to infect fruits both at pre- and post-harvest stages, amounting to a loss of about 10 - 80 per cent (Madalageri and Ukkund, 2004; Sharma *et al*., 2005; Taylor *et al*., 2007; Korpraditskul and Rattanakreetakul, 2004 and Hartman and Wang, 1992).

Collototrichum spp. are cosmopolitan in nature, due to its ability to infect awide range of economic crops including alternate hosts such as tomato, apple, olive, almond, citrus, lupine, peach and strawberry (Kim *et al*., 2016; Rashid *et al*., 2015 and Talhinhas *et al*., 2018) and poly infectious mode of infection namely, seed-borne (Perane and Joi, 1988; Mesta *et al*., 2007 and Machenahalli *et al*., 2014), soil-borne, water-borne and

air-borne (Kallupurackal and Ravindran, 2004).This presents a mounting threat to the commercial production of chilli.

Plants have developed a complex defense system to combat the infection caused by diverse pathogens. Resistance can be the result of several distinct defense mechanisms either singly or in combination which includes constitutive structural barriers and bio-chemical defenses. Several studies on chilli fruit have also suggested that, the presence of defense compounds restrict the infection of anthracnose (Oh *et al*., 1999a and b). In the breeding programme, besides molecular studies to identify resistance source, it is also necessary to determine the biochemical constituents that contribute for resistance to anthracnose. Furthermore, these constituents can be used as indicators as well as predictors for incidence of anthracnose disease in chilli. The objective of the present study was to establish the role of biochemical constituents that contribute to anthracnose resistance in chilli.

MATERIAL AND METHODS

The study was carried out at the Department of Vegetable Science, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore in 2018. One hundred and thirty-two chilli genotypes were grown in Randomized Block Design and visually screened for anthracnose disease in chilli in two replications. All recommended package of practices was followed, except the application of fungicides.

Screening for anthracnose:

Disease severity was assessed at ripened fruit stage which coincide with anthracnose incidence as per the score chart suggested by McKinney (1923).

Score	% of infection
0	No infection
1	Less than 1 %
3	1 - 10%
5	11 - 25%
7	26 - 50%
9	More than 50%

Per cent Disease Index (PDI) was calculated using the formula given by Wheeler (1969). The percentage values of disease severity were transformed into the arcsine values for statistical analysis.

$$PDI = \frac{\text{Sum of individual scores}}{\text{Number of fruits assessed}} \times \frac{100}{\text{Maximum disese score}}$$

Based on PDI, the 0 - 4 grading was followed as suggested by Bansal and Grover (1969).

Estimation of biochemical parameters:

Grade	Percentage of disease index	Reaction
0	No infection	Immune
1	1 – 5%	Resistant
2	6 – 25%	Moderately resistant
3	26 – 50%	Susceptible
4	More than 50%	Highly susceptible

The ripe chilli fruits were analyzed in Bruker Matrix-I Fourier transform near-infrared (FT-NIR) Spectrometer with OPUS 6.5 Software. FT-NIR is non-destructive, quick, reliable and a useful replacement for arduouswet chemical tests and chromatographic methods. This method allows the use of a small sample size without significant previous preparation. Before estimation of capsaicin, capsanthin and oleoresin contents the instrument was calibrated with standard samples of known capsaicin, capsanthin and oleoresin in absorbance mode. FT-NIR spectra were collected from 6000 to 4000 cm^{-1} using 2 cm^{-1} intervals for chilli samples. Each sample was scanned twice using each spectrometer and the final spectrum used was the average of these spectra.

Statistical analysis:

The percentage values of anthracnose disease severity were transformed into the arcsine values for statistical analysis. The correlation co-efficient, direct and indirect effects were computed using multiple regression in excel.

RESULTS AND DISCUSSION

In present study, chilli genotypes were screened for anthracnose resistance under natural conditions in 2018. All the genotypes reacted for anthracnose and the responses differed significantly. Results obtained from the FT-NIR for chilli genotypes exhibited significant differences for both quantitative and qualitative traits (Table 1). The correlation co-efficient study indicated that incidence of anthracnoseat ripe fruit stage was significant and negatively correlated with capsaicin,

Table 1 : Per cent of disease index along results of qualitative and quantitative parameters of the chilli genotypes screened for anthracnose resistance

Genotypes	Severity of anthracnose (PDI)	Capsaicin (%)	Oleoresin (%)	Capsanthin (ASTA)	Fresh fruit yield/plant (g)	Dry fruit yield/plant (g)
Aparna	63.70	0.52	4.71	94.83	93.27	29.97
Assam chilli	68.69	0.43	3.41	93.52	86.41	26.05
Bird's eye chilli	17.85	0.42	5.08	108.94	128.00	38.75
CA 6	72.64	0.39	3.16	91.87	67.28	20.82
CA 7	43.09	0.59	4.79	96.29	146.24	49.09
CA 13/2	86.33	0.42	4.28	89.80	34.53	12.27
CA 13/5	37.69	0.48	5.08	99.79	191.70	53.89
CA 13/6	23.42	0.43	3.98	108.53	253.76	78.74
CA 27	94.75	0.57	2.72	82.05	16.48	7.61
CA 29	87.74	0.66	5.00	88.30	28.26	9.61
CA 30	85.97	0.55	5.05	89.63	36.78	12.92
CA 36	69.72	0.68	4.81	91.28	74.01	25.46
CA 41	82.28	0.31	5.81	91.34	46.33	15.97
CA 45	32.73	0.57	4.20	102.84	211.31	59.87
CA 46	50.57	0.52	4.10	93.94	129.15	38.56
CA 48	87.01	0.45	2.77	89.42	31.93	10.07
CA 52	82.39	0.57	4.27	90.84	46.14	15.43
CA 60	35.49	0.55	3.43	101.72	195.19	55.67
CA 64	39.37	0.55	3.96	97.47	170.34	52.04
CA 67	76.74	0.66	3.50	90.81	59.61	19.00
CA 69	46.22	0.45	2.46	97.54	137.42	42.43
CA 71	30.69	0.36	3.20	107.01	235.36	68.86
CA 77	89.96	0.53	5.46	88.30	27.36	9.25
CA 80	32.94	0.52	4.21	103.45	211.99	58.16
CA 92	45.46	0.55	5.16	95.49	142.15	46.18
CA 94	60.39	0.53	5.92	94.97	100.61	34.06
CA 101	38.09	0.56	4.69	99.21	181.58	53.18
CA 104	68.70	0.55	4.89	92.18	79.33	25.88
CA 107	71.24	0.55	3.84	92.03	70.17	23.17
CA 108	95.35	0.41	3.32	81.12	16.62	6.90
CA 110	45.78	0.54	4.80	95.18	142.49	45.83
CA 116	72.85	0.45	6.45	92.00	67.53	21.13
CA 119	90.86	0.55	5.36	87.07	22.56	8.73
CA 121	85.28	0.57	2.81	90.37	36.88	13.01
CA 126	45.82	0.41	4.89	96.64	138.20	44.16
CA 139	67.78	0.40	4.20	93.05	84.80	26.57
CA 141	60.52	0.43	3.03	93.01	101.63	33.12
CA 157	44.59	0.64	4.29	96.87	146.30	47.57
CA 158	38.12	0.45	4.23	100.01	169.51	51.94
CA 159	31.50	0.57	5.17	102.53	227.55	69.02
CA 161	32.40	0.51	5.57	104.51	218.11	65.34

Table 1 : Contd.....

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CA 164	55.68	0.32	2.79	95.86	112.90	35.77
CA 165	25.70	0.65	4.68	108.02	246.99	75.28
CA 166	21.94	0.42	3.94	109.20	269.50	82.06
CA 167	63.48	0.50	3.05	94.02	99.78	30.74
CA 168	50.69	0.38	2.52	95.74	130.50	37.60
CA 169	86.03	0.56	3.44	89.65	33.75	12.47
CA 171	41.64	0.59	6.20	98.10	163.51	49.68
CA 172	72.62	0.43	4.07	92.77	68.91	21.82
CA 173	86.66	0.52	3.70	89.31	32.50	11.25
CA 175	54.39	0.42	2.68	96.99	116.78	36.12
CA 176	55.08	0.44	3.05	94.62	115.78	35.05
CA 177	10.74	0.57	3.97	140.48	192.58	103.81
CA 178	26.30	0.69	3.70	106.74	243.63	75.17
CA 180	81.37	0.53	5.43	92.21	57.67	17.47
CA 187	32.68	0.85	4.23	100.65	215.30	60.00
CA 188	22.29	0.58	4.47	111.26	270.77	81.79
CA 207	40.05	0.56	3.34	99.13	161.40	53.10
CA 436	73.79	0.53	5.01	91.35	64.98	19.87
CA 620	55.76	0.69	3.29	93.89	110.54	34.57
CA 624	67.56	0.51	3.83	93.26	83.89	26.88
CF 2	64.26	0.56	3.62	92.70	86.16	28.35
Chilli CO Hybrid 1	24.36	0.44	2.42	108.24	248.61	75.77
CO 1	20.82	0.55	6.33	110.58	281.49	83.69
CP 960	54.87	0.52	2.43	94.57	119.04	35.19
EC 339043	90.66	0.48	2.67	87.24	26.14	8.86
EC 339044	90.86	0.53	3.25	87.72	24.37	8.68
EC 402109	51.95	0.42	3.23	94.92	128.49	36.54
EC 570008	56.46	0.24	3.74	93.95	104.37	34.22
EC 572484	95.64	0.41	3.75	67.74	14.28	4.20
EC 599960	31.85	0.40	2.55	102.77	223.54	68.66
EC 599981	82.46	0.45	2.79	92.57	45.12	14.90
EC 600023	64.09	0.48	3.66	94.70	89.69	29.49
Elephant Chilli	92.30	0.45	3.70	81.49	16.92	7.79
Erode Local	87.27	0.36	3.10	90.30	29.13	9.96
F 1	78.74	0.51	5.98	89.76	58.22	16.62
F 2	46.80	0.51	4.74	96.61	138.76	40.93
F 3	69.99	0.51	1.59	91.95	73.68	23.94
F 4	91.86	0.53	3.53	84.77	16.99	8.07
F 5	95.40	0.55	2.66	80.55	15.18	6.06
F 6	35.16	0.48	1.39	100.92	203.75	55.73
F 101	69.26	0.21	2.36	91.88	74.75	25.35
F 102	82.01	0.47	5.56	90.51	50.17	15.99
F 410	81.82	0.36	5.12	90.29	54.63	17.16

Table 1: Contd……..

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F 507	17.17	0.56	4.52	110.41	218.99	94.09
F 701	42.54	0.30	2.36	97.85	151.27	49.53
F 702	90.15	0.45	5.60	87.98	27.18	8.95
F 706	41.81	0.47	4.65	98.14	160.87	50.25
F 707	46.88	0.49	5.85	96.78	130.73	39.81
G 3	95.44	0.49	3.75	75.76	14.42	5.62
Gokak Local	86.95	0.55	3.45	89.20	31.81	10.17
IC 336254	73.85	0.50	4.44	91.58	65.53	20.86
IC 342465	24.68	0.80	4.15	106.38	251.04	76.72
IC 344327	37.95	0.53	4.66	99.58	183.30	53.30
IC 344386	87.36	0.56	5.51	89.02	28.44	10.05
IC 361979	90.38	0.58	3.94	87.70	27.09	8.90
IC 361982	31.20	0.61	5.39	103.78	232.37	69.20
IC 572485	28.54	0.52	3.20	105.79	240.94	71.52
Jayanthi	86.61	0.56	5.29	90.38	32.52	11.92
Jeynthi	91.00	0.28	4.17	85.38	18.13	8.30
Kadaladi 1	19.70	0.40	2.71	112.00	264.82	85.48
KMD/PY 1	32.49	0.36	2.84	104.28	212.68	64.02
LCA 206	37.75	0.51	5.91	101.01	191.62	52.35
LCA 235	63.93	0.51	5.33	91.61	91.11	29.02
LCA 625	51.81	0.48	4.26	96.30	126.98	37.78
Long Chilli	32.98	0.60	4.18	102.30	210.69	56.09
M 8	90.93	0.54	5.86	86.39	22.79	8.62
M 10	84.64	0.35	2.33	90.11	42.68	12.95
M 101	42.16	0.45	3.13	96.98	159.01	50.12
M 102	42.61	0.52	5.90	97.73	154.46	48.87
M 103	42.59	0.47	3.59	98.45	149.18	48.60
M 105	59.90	0.50	3.98	94.19	102.03	33.67
M 106	69.35	0.49	4.84	92.71	74.17	24.90
M 412	54.26	0.40	2.64	93.07	119.63	37.53
M 413	38.11	0.53	4.40	99.58	169.90	51.08
M 415	33.59	0.44	3.60	103.22	205.71	57.12
M 501	35.72	0.22	2.91	100.80	198.72	54.08
M 704	29.55	0.57	5.74	105.68	241.98	69.22
M 707	73.57	0.23	3.57	90.34	68.13	21.04
M 708	76.42	0.51	5.17	90.09	64.95	19.58
M 714	65.04	0.46	4.51	91.80	86.08	26.94
MP 1	77.95	0.55	4.95	90.48	59.85	17.27
Paramakudi 1	16.64	0.62	5.72	137.06	357.93	94.98
Paramakudi 2	22.45	0.67	3.72	109.21	253.02	80.27
Paranthaman Local	94.92	0.50	3.31	82.12	16.76	7.17
PLR 1	96.42	0.44	5.41	65.84	51.52	14.37
Ramnad Local	20.64	0.56	5.50	111.05	285.21	85.81
Sankarankovil Local	68.90	0.20	3.22	91.87	75.56	24.84
TA/CA/10	21.56	0.56	4.98	111.18	276.79	84.54
TA/CA/17	45.13	0.45	5.82	95.94	142.43	46.37
Ujjwala	72.40	0.46	3.88	93.25	70.04	22.16
West Bengal	82.46	0.48	3.29	91.41	44.26	13.77
S.E.±	1.11	0.02	0.15	1.35	1.94	0.73
C.D. (P=0.05)	2.18	0.04	0.29	2.67	3.85	1.45
C.V. (5%)	2.33	3.88	3.61	1.41	1.62	1.96

Table 2: Pearson correlation co-efficient r critical values in bold letters show negative correlations (t- test, α=0.05)

	Anthracnose PDI	Capsaicin (%)	Oleoresin (%)	Capsanthin (ASTA)	Fresh fruit yield /plant (g)	Dry fruit yield /plant (g)
Anthracnose PDI	1	-0.161	-0.060	-0.882	-0.955	-0.962
Capsaicin (%)		1	0.307	0.195	0.209	0.214
Oleoresin (%)			1	0.083	0.074	0.066
Capsanthin (ASTA)				1	0.865	0.902
Fresh fruit yield/plant (g)					1	0.977
Dry fruit yield /plant (g)						1

Table 3 : Multiple regression analysis summary

	Co-efficients	Standard error	t Stat	*p* -value
Capsaicin (%)	7.314	3.640	2.010	0.046612**
Oleoresin (%)	-0.070	0.339	-0.206	0.836785
Capsanthin (ASTA)	-0.174	0.087	-1.999	0.047811**
Fresh fruit yield/plant (g)	-0.072	0.021	-3.443	0.000782*
Dry fruit yield/plant (g)	-0.321	0.081	-3.956	0.000126*

Note : * and ** indicate significance of values at P=0.05 and 0.01, respectively

capsanthin and oleoresin content (Table 2). Incidentally, moderately resistant genotypes identified under field conditions were found to be significantly superior with respect to capsaicin, oleoresin and fruit yield. In the order of merit, the fifteen genotypes with PDI for anthracnose, capsaicin and oleoresin content were CA 177 (10.74%, 0.57%, 3.97%), Paramakudi 1 (16.64%, 0.62%, 5.72%), F 507 (17.17%, 0.56%, 4.52 %), Bird's eye chilli (17.85%, 0.42%, 5.08%), Kadaladi 1 (19.70%, 0.40%, 2.71%), Ramnad local (20.64%, 0.56%, 5.50%), CO 1 (20.82%, 0.55%, 6.33%), TA/CA/10 (21.56%, 0.56%, 4.98%), CA 166 (21.94%, 0.42%, 3.94%), CA 188 (22.29%, 0.58%, 4.47%), Paramakudi 2 (22.45%, 0.67%, 3.72%), CA 13/ 6 (23.42%, 0.43%, 3.98%), Chilli CO hybrid 1 (24.36%, 0.44%, 2.42%), IC 342465 (24.68%, 0.80%, 4.15%) and CA 165 (25.70%, 0.65%, 4.68%). whereas, lower levels of capsaicin and oleoresin were found in highly susceptible genotypes.

From the multiple regression analysis, it is evident that, capsaicin, capsanthin, fresh fruit weight/plant and dry fruit weight/plant had significant linear relationship with anthracnose incidence in chilli (Table 3). Earlier studies reported that anthracnose disease was more severe with greater prevalence of mycelium on immature fruits than ripen fruits, this may be due to lower levels of capsaicin and oleoresin (Oh *et al*., 1998; Kim *et al*., 1999 and Ko *et al*., 2005). Corroborating the findings of present investigation, Azad 1991; Tenaya *et al*., 2001 and Kraikruan *et al*., 2008 have reported that, higher capsaicin and oleoresin content in red chilli indicated resistance to anthracnose. Hence, capsaicin and oleoresin content can be used as an indirect tool to predict anthracnose resistance in chilli.

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