STUDIES ON BIOCHEMICAL CHANGES IN HEALTHY AND INFECTED TURMERIC RHIZOME (*CURCUMA LONGA* L.)

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ABSTRACT

The biochemical changes were studied from healthy and infected rhizomes of *Curcuma longa* L. due to leaf spot (*Colletotrichum gloeosporioides* L.) infection. Due to fungal infection curcumin content was recorded to be increasing in diseased plants as compared to healthy plants in different genotypes. Phenol content was also recorded to be increasing due to the disease. Genotypes which are resistant to leaf spot contained higher amount of phenol as compared to the susceptible one. While in case of sugar, non-reducing, reducing and total sugar content was recorded to be lower in diseased leaves as compared to the healthy leaves in all the genotypes.

***Key words*:** Turmeric, Leaf spot, Biochemical, Curcumin, Phenol, Sugar

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Introduction:

Turmeric (*Curcuma longa* L.) (Family: Zingiberaceae) is one of the major spices cultivated for its underground rhizome, which is also called as "hidden Lilly" or "turmeric of commerce". The yield of turmeric has been reported to vary greatly depending on cultivars, climate, planting time and maturity at harvest. Turmeric is the dried rhizome and the major constitutes contains appreciable quantities of protein (6.3%), lipids (5.1%), carbohydrates (69.4%) and fats (8.9%). Turmeric is rich in minerals like phosphorus, calcium, iron and vitamin A. Active compounds in turmeric are typically classified as non volatile and volatile. Major non volatile curcuminoids are curcumin, demethoxycurcumin and bisdemethoxycurcumin. Curcumin is the pigment that lends to develop the bright stunning yellow colour of turmeric (Vergheses, 1999). Additionally, anti-cancer and antiviral activities of turmeric may also increase its demand from pharmaceutical industry. Total 14 diseases caused by fungi, bacteria and viruses have been reported in different parts of the world. Among them, leaf spot caused by different species of *Colletotrichum*. is one of the destructive disease which cause considerable biochemical changes in turmeric. Such biochemical changes in rhizome reduce their market value considerably.

Materials and Methods

Estimation of biochemical components such as curcumin, total phenols and sugars (reducing, non-reducing and total sugars) content were carried out from twenty two genotypes of turmeric from the varietal screening field experiment conducted during 2008-09 in randomized block design with three replications. The leaves and rhizomes from the healthy and diseased plants were taken separately in paper bags. The leaves were cut into small pieces, put in paper dishes and oven dried at 50^0 C. The roots were separated from the rhizomes and washed with tap water. The rhizome were cut into small pieces, put in paper dishes and dried in oven at 50^0 C temperature.

The dried samples of leaves and rhizomes were grind in laboratory grinder and sieved with test sieves, Mesh No. 80 to prepare fine powder. The samples prepared for chemical analysis were filled in small polythene bags. Estimation of curcumin (Sadasivam and Manickam, 1992) phenol (Bray and Thorpe, 1954), reducing sugar, non-reducing sugar, total sugar (Sadasivam and Manickam, 1992) from leaves and rhizomes were analyzed and worked out by standard available methods.

Results and Discussion:

Healthy and diseased leaves and rhizomes from all the genotypes (Resistant, Moderately resistant, moderately susceptible and susceptible genotypes) were

collected from the field. The leaves and rhizomes were bio-chemically analyzed for curcumin, total phenol, reducing sugars, non-reducing sugars and total sugars (Table 4.5 to 4.8) and Fig. 2.

Curcumin content

The results revealed a higher curcumin content in diseased plants as compared to healthy plants of all the genotypes tested (Table 4.5). In healthy plants, curcumin content was in the range of 1.46 to 3.73 per cent (Av. 2.76%), whereas in diseased plants, it was in the range of 1.68 to 4.20 per cent (Av. 3.28%).The per cent increase of curcumin (Fig. 2) was highest in infected plants of NVST 36 (44.36%), while it was lowest in NVST-45 (5.45%). Average per cent increase in curcumin content in resistant, moderately resistant, moderately susceptible and susceptible genotypes was 11.47, 20.31, 12.10 and 13.10 (Table 4.6), respectively.

Data presented in Table 4.6 clearly showed that curcumin content increased in plants infected with *C. gloeosporioides*. It also showed the vast differences between the curcumin content of all the genotypes might be due to the genetical variation.

These results are in agreement with the finding of Nair and Ramakrishanan (1973) who reported 38.61 per cent increase in curcumin content in diseased plants of turmeric.

Total Phenol

The results revealed a higher phenol content in diseased leaves as compared to the healthy leaves of all the genotypes tested (Table 4.5). In healthy leaves, total phenol content was in the range of 0.33 to 0.55 mg/g (Av. 0.45 mg/g). Whereas, in diseased leaves, it was in the range of 0.34 to 0.56 mg/g (Av. 0.47 mg/g). Data clearly revealed that total phenol was higher in resistant genotypes as compared to susceptible genotypes. Average per cent increase in phenol content in resistant, moderately resistant, moderately susceptible and susceptible genotypes were 2.76, 3.20, 5.02 and 5.84 per cent (Table 4.6 and Fig. 2), respectively.

There was a vast difference in phenol content of healthy and diseased leaves in different genotypes. It is very clear from this study that the phenol content in the leaves increased with the infection of the pathogen.

These results are in agreement with the finding of Kulkarni (2009) who reported that healthy leaves of resistant and moderately resistant genotypes contained higher amount of total phenol than susceptible one. The increase in phenol content was at higher rate in resistant and moderately resistant genotypes compared to susceptible genotypes.

Sugar

Non Reducing sugar

Analysis of biochemical constituent revealed that non reducing sugar content was lower in diseased leaves as compared to healthy leaves in all the genotypes tested.

In healthy leaves non reducing sugar was in the range of 17.67 to 32.13 mg/g (Av. 26.22 mg/g). Whereas in diseased leaves, it was in the range of 9.62 to 19.42 mg/g (Av. 16.52 mg/g). Per cent decrease of non reducing sugar in diseased leaves over healthy leaves was in the range of 18.89 to 61.04 per cent (Av. 37.32%) (Table 4.7).

Average per cent decrease of non reducing sugar in diseased leaves over healthy leaves of resistant, moderately resistant, moderately susceptible and susceptible genotypes was 26.03, 40.59, 43.76 and 61.04 per cent, respectively (Table 4.8).

Reducing sugar content

The results revealed a lower reducing sugar content in diseased leaves as compared to healthy leaves of all the genotypes tested.

In healthy leaves, reducing sugar was in the range of 26.52 to 49.47 mg/g (Av. 38.64 mg/g), whereas in diseased leaves, it was in the range of 12.72 to 24.54 mg/g (Av. 19.60 mg/g). Per cent decrease of reducing sugar in diseased leaves over healthy leaves was in the range of 34.48 to 69.23 per cent (Av. 48.79%) (Table 4.7).

Average per cent decrease of reducing sugar in diseased leaves over healthy leaves of resistant, moderately resistant, moderately susceptible and susceptible genotypes was 38.64, 50.14, 63.05 and 62.12 per cent, respectively (Table 4.8).

Total sugar

The results revealed a lower total sugar content in diseased leaves as compared to healthy leaves of all the genotypes tested.

In healthy leaves, total sugar was in the range of 44.19 to 80.92 mg/g (Av. 64.86 mg/g), whereas in diseased leaves, it was in the range of 22.34 to 43.29 mg/g (Av. 36.12 mg/g). Per cent decrease of total sugar in diseased leaves over healthy leaves was in the range of 29.01 to 61.66 per cent (Av. 44.18 %) (Table 4.7).

Changes in curcumin and phenol content in turmeric genotypes infected with *C. gloeosporioides*

Sr. No.	Genotype	Curcumin (%)		Increase (%)	Total Phenol (mg/g)		Increase (%)
		Healthy	Diseased		Healthy	Diseased	
1*	NVST-1	3.58	3.90	8.21	0.53	0.55	3.55
2	NVST-2	3.25	3.65	10.96	0.55	0.56	2.04
3	NVST-4	1.64	1.96	16.33	0.50	0.50	1.12
4	NVST-39	3.36	3.56	5.62	0.51	0.53	2.51
5	NVST-40	3.20	3.60	11.11	0.48	0.50	3.96
6	NVST-49	3.21	3.42	6.08	0.49	0.52	4.80
7	NVST-50	2.98	3.82	21.99	0.52	0.53	1.38
8	NVST-5	1.46	1.68	13.10	0.48	0.50	4.07
9	NVST-34	2.14	3.10	30.97	0.41	0.42	2.23
10	NVST-35	1.50	1.68	10.71	0.43	0.45	4.16
11	NVST-36	1.48	2.66	44.36	0.34	0.34	2.12
12	NVST-38	3.41	4.12	17.23	0.51	0.53	3.53
13	NVST-41	1.60	1.82	12.09	0.51	0.52	2.12
14	NVST-42	1.78	2.12	16.04	0.40	0.43	5.42
15	NVST-43	2.56	3.86	33.68	0.35	0.35	1.76
16	NVST-45	3.64	3.85	5.45	0.45	0.46	2.01
17	NVST-47	2.87	3.82	24.87	0.50	0.52	4.22
18	NVST-48	3.20	3.76	14.89	0.50	0.52	3.52
19	NVST-46	3.32	3.68	9.78	0.40	0.42	5.64
20	NVST-51	3.13	3.96	20.96	0.35	0.37	4.99
21	Kesar	3.73	3.95	5.57	0.33	0.34	4.44
22	Sugandham	3.65	4.20	13.10	0.41	0.44	5.84
Average		2.76	3.28	16.05	0.45	0.47	3.43

* 1 to 7- Resistant
8 to 18- Moderately Resistant
19 to 21- Moderately Susceptible
22- Susceptible

Per cent increase in phenol and curcumin content of diseased leaves over healthy leaves

Rating	Genotypes	Av. Curcumin (%)		Increase (%)	Av. Phenol (mg/g)		Increase (%)
		Healthy	Diseased		Healthy	Diseased	
R	NVST-1, NVST-2 , NVST-4, NVST-39, NVST-40, NVST-49, NVST-50	3.03	3.42	11.47	0.51	0.53	2.76
MR	,NVST-5, NVST-34, NVST-35, NVST-36, NYST-38, NVST-41, NVST-42, NVST-43, NVST-45, NVST-47, NVST-48,	2.33	2.95	20.31	0.44	0.46	3.20
MS	Kesar, NVST-51, NVST-46	3.39	3.86	12.10	0.36	0.38	5.02
S	Sugandham	3.73	3.95	13.10	0.33	0.34	5.84

Changes in sugar content of turmeric genotypes infected with *C. gloeosporioides*

Sr. No.	Genotype	Non Reducing (mg/g)		Decrease (%)	Reducing (mg/g)		Decrease (%)	Total Sugar (mg/g)		Decrease (%)
		Healthy	Diseased		Healthy	Diseased		Healthy	Diseased	
1	NVST-1	17.67	14.30	19.07	26.52	16.76	36.80	44.19	31.06	29.71
2	NVST-2	20.80	16.87	18.89	32.90	20.47	37.78	53.70	37.34	30.47
3	NVST-4	22.80	16.73	26.62	31.69	19.83	37.43	54.49	36.56	32.91
4	NVST-39	21.06	16.78	20.32	33.41	21.89	34.48	54.47	38.67	29.01
5	NVST-40	23.90	16.89	29.33	32.89	19.84	39.68	56.79	36.73	35.32
6	NVST-49	25.86	16.80	35.03	38.21	22.57	40.93	64.07	39.37	38.55
7	NVST-50	27.96	18.75	32.94	43.36	24.54	43.40	71.32	43.29	39.30
8	NVST-5	27.66	16.89	38.94	34.92	20.56	41.12	62.58	37.45	40.16
9	NVST-34	25.86	16.56	35.96	38.36	18.46	51.88	64.22	35.02	45.47
10	NVST-35	30.13	16.87	44.01	46.68	21.72	53.47	76.81	38.59	49.76
11	NVST-36	29.51	17.45	40.87	41.54	18.95	54.38	71.05	36.40	48.77
12	NVST-38	30.72	19.42	36.78	44.22	20.32	54.05	74.94	39.74	46.97
13	NVST-41	24.70	15.92	35.55	33.90	16.78	50.50	58.60	32.70	44.20
14	NVST-42	24.71	16.85	56.09	36.97	19.05	59.29	61.68	35.90	58.01
15	NVST-43	27.96	16.75	40.09	45.36	22.54	50.31	73.32	39.29	46.41
16	NVST-45	26.36	18.86	28.45	38.62	22.34	42.15	64.98	41.20	36.60
17	NVST-47	27.46	17.60	35.91	39.72	22.80	42.60	67.18	40.40	39.86
18	NVST-48	22.66	10.45	53.88	34.92	16.82	51.83	57.58	27.27	52.64
19	NVST-46	31.45	18.72	40.48	49.47	15.22	69.23	80.92	33.94	58.06
20	NVST-51	30.72	17.42	43.29	44.22	19.32	56.31	74.94	36.74	50.97
21	Kesar	32.13	16.87	47.49	48.68	17.72	63.60	80.81	34.59	57.20
22	Sugandham	24.69	9.62	61.04	33.58	12.72	62.12	58.27	22.34	61.66
Average		26.22	16.52	37.32	38.64	19.60	48.79	64.86	36.12	44.18

Per cent decrease of sugar content in diseased leaves over healthy leaf

Rating	Genotypes	Non Reducing			Reducing			Total Sugar		
		Healthy	Infected	Decrease (%)	Healthy	Infected	Decrease (%)	Healthy	Infected	Decrease (%)
R	NVST-1, NVST-2, NVST-4, NVST-39, NVST-40, NVST-49 NVST-50	22.86	16.73	26.03	34.14	20.84	38.64	57.00	37.57	33.61
MR	NVST-5, NVST-34, NVST-35, NVST-36, NYST-38, NVST-41, NVST-42, NVST-43, NVST-45, NVST-47, NVST-48	27.07	16.69	40.59	39.56	20.03	50.14	66.63	36.72	46.26
MS	Kesar, NVST-51, NVST-46	31.43	17.67	43.76	47.46	17.42	63.05	78.89	35.09	55.41
S	Sugandham	24.69	9.62	61.04	33.58	12.72	62.12	58.27	22.34	61.66

Average per cent decrease of total sugar in diseased leaves over healthy leaves of resistant, moderately resistant, moderately susceptible and susceptible genotypes was 33.61, 46.26, 55.41 and 61.66 per cent, respectively (Table 4.8). Data presented in Table 4.8 clearly indicated that sugar content of turmeric leaves infected with *C. gloeosporioides* decreased at higher rates in susceptible and moderately susceptible genotypes as compared to the resistant and moderately resistant genotypes.

These results are in agreement with the findings of Kulkarni (2009) who reported higher total sugar, reducing sugar and non-reducing sugar contents in healthy leaves of susceptible genotypes than the resistant ones to anthracnose (*C. truncatum*) of green gram while Kulkarni (2008) showed that sugar content of leaves infected with *C. truncatum* (green gram) decreased at higher rates in susceptible varieties compared to resistant and moderately resistant varieties. The finding in the present study is the new information.

Conclusion:

Biochemical changes in the leaves and rhizomes due to leaf spot disease were studied. Curcumin content was recorded to be higher in diseased plants as compared to the healthy plants in different genotype tested. The per cent increase of curcumin content in diseased plant was in the range of 5.45 to 44.36 per cent.

Diseased leaves contained higher amount of phenol as compared to healthy leaves of all the genotypes tested. Average per cent increase in phenol content in resistant, moderately resistant, moderately susceptible and susceptible genotypes was 2.76, 3.20, 5.02 and 5.84 per cent, respectively. Total phenol content was found to be higher in resistant genotypes as compared to the susceptible genotypes.

Non-reducing, reducing and total sugar content was recorded to be lower in diseased leaves as compared to the healthy leaves in all the genotypes tested. Overall, decrease in non reducing sugar was ranging from 18.89 to 61.04 (Av. 37.32%), reducing sugar from 34.48 to 69.23 (Av. 48.79%) and total sugar from 29.01 to 61.66 per cent (Av. 44.18%)

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