

Grape Downy Mildew in India: Effect of Infection on Plant Pigments

By

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ABSTRACT

In grape leaves of five different colours infected by downy mildew, the contents of total chlorophyll and anthocyanin were reduced. On the other hand, the contents of carotene and xanthophyll increased in infected leaves. An enhanced activity of chlorophyllase was noticed in infected leaves of all ages and grades of infection.

INTRODUCTION

The incidence of downy mildew of grapes caused by *Plasmopara viticola* (B. & C.) Berl. and De T., in grape leaves of different ages as indicated by the leaf colour was reported (Srinivasan and Jeyarajan, unpublished). Since yellow discolouration on the upper surface of leaves was a prominent symptom of the disease, the contents of plant pigments like chlorophyll, carotene, xanthophyll and anthocyanin in healthy and infected leaves were estimated. The effect of infection on the content of plant pigments in leaves of different ages is presented in this paper.

MATERIALS AND METHODS

In grape variety Anab-e-Shahi, viridian green, agathia green and emerald green leaves showing three grades of infection by *P. viticola* and healthy leaves were collected as reported earlier (Srinivasan and Jeyarajan, *loc. cit.*). The total chlorophyll

content was estimated by the modified method of Smith and Benitez (1955). Chlorophyllase activity was estimated by the modified colorimetric method of Holden (1961). The enzyme activity was expressed as percentage of the substrate split in a given time, one unit being the amount which will catalyse the break down of 10 per cent of the substrate to chlorophyllide in one hour. Xanthophyll and carotene were estimated by the method of Snell and Snell (1937). The content of anthocyanin was estimated by the method of Rutland and Sea Wright (1973).

RESULTS AND DISCUSSION

The content of chlorophyll, carotene, xanthophyll and anthocyanin pigments and activity of chlorophyllase in healthy and diseased leaves is presented in Table 1. Since downy mildew growth did not appear in young leaves (red and jade green), only healthy leaves in these colours were analysed.

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TABLE 1. Contents of pigments and activity of chlorophyllase in healthy and downy mildew infected grape leaves

Leaf colour	Disease grade	Chlorophyll mg/g		Chlorophyllase activity		Carotene mg/g		Xanthophyll mg/g		Anthocyanin	
		Content	Diseased Healthy (per cent)	Units	Diseased Healthy (per cent)	Content	Diseased Healthy (per cent)	Content	Diseased Healthy (per cent)	OD of extract	Diseased Healthy (per cent)
Red	0	0.53	—	0.22	—	0.10	—	0.04	—	1.09	—
Jade green	0	1.01	—	0.25	—	0.35	—	0.11	—	0.46	—
Viridian green	0	1.30	—	0.26	—	0.17	—	0.05	—	0.49	—
	1	0.36	27.8	0.39	150.0	0.24	135.1	0.18	404.4	0.38	77.5
	2	0.29	22.6	0.40	153.8	0.23	131.6	0.09	211.1	0.34	70.2
	3	0.28	21.1	0.66	253.8	0.19	109.2	0.07	162.2	0.42	86.5
Agathia green	0	1.54	—	0.26	—	0.17	—	0.06	—	0.55	—
	1	0.89	57.9	0.48	184.6	0.32	180.8	0.11	187.0	0.50	90.6
	2	0.52	33.5	0.56	215.4	0.31	175.1	0.08	135.4	0.47	85.1
	3	0.46	30.1	0.70	269.2	0.29	165.5	0.07	124.1	0.53	96.7
Emerald green	0	2.17	—	0.32	—	0.22	—	0.07	—	0.59	—
	1	0.74	34.0	0.52	162.5	0.43	195.9	0.15	207.1	0.56	94.6
	2	0.56	25.6	0.83	259.4	0.42	190.5	0.12	165.7	0.54	91.2
	3	0.45	20.9	1.38	431.2	0.35	157.6	0.10	138.5	0.58	98.2
t value Healthy vs Diseased		6.48*		5.23*		5.36*		3.85*		4.20*	

0—Healthy 1, 2, 3—Grades of infection * Significant at P = 0.05

Chlorophyll: In all infected leaves the content of total chlorophyll was significantly less than in healthy leaves. Such reductions were more in leaves showing higher infection grades. The greatest reduction was noticed in grade 3 infection in emerald green leaves but least in grade 1 infection in agathia green leaves. When infected leaves of the three colours were compared, the maximum reduction was noticed in viridian green leaves which contained only 23.81 per cent of the chlorophyll content of healthy leaves. The least reduction was observed in agathia green leaves. The reduction in leaves of each infection grade in the three colours also followed a similar trend.

Chlorophyllase activity: In order to find out whether the reduction in chlorophyll content in infected leaves was due to any increase in enzymatic activity, the chlorophyllase activity was estimated in leaves of different colours with different infection grades. The data indicated that chlorophyllase activity in infected leaves was significantly greater than in healthy leaves. In infected leaves of the three colours the activity of this enzyme was maximum in infection grade 3. The maximum increase was noticed in emerald green leaves with infection grade 3 where it increased four folds over healthy leaves. The least reduction was noticed in viridian green leaves showing infection grade 1. When infected leaves of the three colours were compared, the greatest increase in activity was noticed in emerald green leaves and the least increase in viridian green leaves.

Carotene: In all infected leaves the carotene content was significantly higher than in healthy leaves. Such increases were on par in leaves showing infection grades 1 and 2. The per cent increase was greatest in emerald green leaves showing infection grade 1 but least in viridian green leaves showing infection grade 3.

Xanthophyll: In all infected leaves the content of xanthophyll was higher than the comparable healthy leaves. Such increases were on par in leaves showing infection grades 1 and 2. The per cent of increase was highest in viridian green leaves showing infection grade 1 and least in grade 3 infection in agathia green leaves.

Anthocyanin: In infected leaves the content of anthocyanin was significantly less than the healthy leaves and in infected leaves of all colours the lowest level of anthocyanin was seen in grade 2. The greatest reduction was noticed on infection grade 2 in viridian green leaves and least in emerald green leaves showing infection grade 3. In the infection grade 3 in all the three coloured leaves, the anthocyanin content was higher than in leaves with other grades of infection.

The results revealed that several interrelated physiological changes took place in the plant as a result of infection by *Plasmopara viticola*. The chlorophyll content was not a limiting factor for downy mildew infection in leaves as evidenced by the fact that red and green with orange leaves were also infected. Morel (1944) showed that grape leaves devoid of chlorophyll were covered with sporangioophores of the

pathogen. The present investigation has furnished corroborative evidence in support of this finding. The chlorophyll content and chlorophyllase activity were negatively correlated. Unlike the content of chlorophyll, the contents of carotene and xanthophyll were found to increase in infected leaves. As such, yellow discolouration on the upper surface of infected grape leaves is primarily due to the reduction in chlorophyll.

Like the chlorophyll content, the anthocyanin content decreased in infected leaves. Link *et al.* (1929) mentioned protocatechuic acid, a constituent of anthocyanin pigment retarded the growth of the mycelium of *Colletotrichum circinans* (Berk.) Vogl. The incubation period of the fungus in red leaves was higher than leaves of other colours by eight days (Srinivasan and Jeyarajan, *loc. cit.*), Considering the fact that red leaves had about twice the quantity of anthocyanins as in leaves of other colours, it is possible that some ingredients of this pigment retarded the rate of growth of the mycelium of the pathogen. The effect of protocatechuic acid on *C. circinans* lends support to this view.

ACKNOWLEDGEMENT

The senior author thanks the Indian Council of Agricultural Research, New

Delhi for the award of junior fellowship during the tenure of which the present investigations were carried out. He also thanks the Tamil Nadu Agricultural University, Coimbatore for according permission to publish the thesis submitted for the award of M. Sc. (Ag.) degree in Plant Pathology.

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