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MORPHO-BIOCHEMICAL BASIS OF RESISTANCE AGAINST *CNAPHALOCROCIS MEDINALIS* GUENEE IN SOUTH GUJARAT

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ABSTRACT

The study aimed to investigate the morpho-biochemical basis of resistance to the rice leaf folder *Cnaphalocrocis medinalis* in ten rice varieties, at the Main Rice Research Centre Farm, Navsari Agricultural University, Navsari, Gujarat during kharif 2021. The width of the leaves varied among the varieties, with GNR-2, GNR-6, GNR-7, and GR-15 having the smallest leaves and TN-1 and GNR-4 having the largest. There was a significant positive correlation between leaf width and infestation. Analysis of chlorophyll, sugar, and protein content in the leaves showed that TN-1 had the highest levels at both 30 days and 50 days after transplanting (DAT), while GR-15 had the lowest. These factors were positively correlated with infestation. On the other hand, phenol content was the highest in GR-15 and lowest in TN-1, with a significant negative correlation with infestation. Chlorophyll, sugar, and protein content increased with higher infestation levels while phenol content decreased.

Key words: Biochemical characters, chlorophyll, *Cnaphalocrocis medinalis,* infestation, leaf width, morphological characters, phenol, protein, resistance, rice, south Gujarat, sugar

Rice *Oryza sativa* L., belongs to the family Poaceae, is the world's most important food crop. In India, rice occupies a 44 million ha area with a production of 124 million tons (Mt) and mean productivity of 2818.18kg/ha (Anonymous, 2022). Its productivity is reduced due to various biotic and abiotic factors. Among biotic factors, a hundred species of insect pests are known. The insect pests causing major damage include yellow stem borer *Scirpophaga incertulas* (Walker), leaf folder *Cnaphalocrocis medinalis* (Guenee), brown planthopper *Nilaparvata lugens* (Stal), gall midge *Orseolia oryzae* (Wood-Mason), whitebacked planthopper (WBPH) *Sogatella furcifera* (Horvath), and green leaf hopper *Nephotettix virescens* (Distant) (Pathak and Dhaliwal, 1981) of these *C. medinalis* is a predominant foliage feeder and one of the most destructive. Earlier, *C. medinalis* was a minor pest, now it has achieved the status of a major pest of rice due to the cultivation of high-yielding varieties and continuous availability of rice crops (Loevinsohn et al.*,* 1993; Bairwa et al., 2023). It causes 18.3% to 58.4% of leaf damage (Ramasamy and Jaliecksono, 1996). Heavy infestations of this pest cause 60 to 70% leaf damage (Kushwaha and Singh, 1984) leading to significant yield losses. The second instar larvae glue to the growing leaves longitudinally for shelter and feed voraciously on green foliage which results in papery dry leaves. Feeding on paddy leaves often results in stunting, curling and finally yellowing. Severe infestation may annihilate the plant (Nirala et al., 2015). The use of insecticides increases the chance for resistance (Nadarajan and Skaria, 1988). Chemical and enzymatic changes within the plant can influence herbivore establishment, feeding, oviposition, growth, development, fertility, and fecundity (Baldwin, 1999). Various plant characteristics such as leaf length and leaf width have a significant impact on the settling, and feeding by *C. medinalis* (Islam and Karim, 1997). The identification of resistant rice germplasms and understanding their mechanism of resistance have played a crucial role (Alagar et al., 2007). The knowledge of biochemical and morphological characters is crucial for the detection of *C. medinalis* resistant genotypes. Taking this into account, this study evaluates the morpho-biochemical basis of resistance.

MATERIALS AND METHODS

The study was conducted under field conditions at the Main Rice Research Centre farm, Navsari Agricultural University, Navsari, Gujarat, India during kharif-2021. Morphological traits, including leaf length and width, were evaluated in ten rice varieties, NAUR-1, GNR-2, GNR-3, GNR-4, GNR-5, GNR-6, GNR-7, GR-15, GR-11, and TN-1. Measurements of leaf length and width were taken using a scale on 10 randomly selected hills. Data collection began 30 days after transplanting (DAT) and continued at 10-day intervals until crop maturity (30, 40, 50, 60, 70, 80, 90, 100, and 110 DAT). Biochemical analyses were carried out at the Department of Agricultural Chemistry and Soil Science, Navsari Agricultural University, Navsari, Gujarat, India. The biochemical parameters, phenol, protein, sugar, and chlorophyll content were measured at two stages: 30 DAT (initial stage) and 50 DAT (peak stage of infestation of *C. medinalis*). For each treatment, samples of 10 fresh leaves (upper, middle, and lower leaves were collected for this. The chlorophyll content of 10 rice leaves was determined using a specialized instrument, known as the SPAD value. The total phenol content was estimated using the Folin-Ciocalteau method, as outlined by Bray and Thorpe (1954). Additionally, the total soluble sugar content of 10 infested leaves was estimated using Anthrone reagents. The protein content was determined using the micro-kjeldahl method, with slight modifications Sadashivam and Manickam, 1992. The data obtained from various morpho-biochemical characteristics were correlated with *C. medinalis* infestation.

RESULTS AND DISCUSSION

The data in Table 1 illustrates the variation in leaf width from 30 to 110 DAT. Initially, at 30 DAT, the smallest mean leaf width of 10.25± 0.60cm was observed in GNR-2, while the largest mean width of 12.04± 0.90cm was recorded in TN-1. As time progressed, at 40 DAT, GNR-2 had the smallest mean leaf width of 11.43± 0.67cm, whereas TN-1 had the largest mean width of 14.22± 0.95 cm. At 50 DAT, GR-15 exhibited the smallest mean leaf width of 12.79± 1.13 cm, while TN-1 had the largest mean width of 14.33± 1.77 cm. At 60 DAT, GR-15 had the smallest mean leaf width of 13.36± 0.92cm, and GNR-4 had the largest mean width of 15.47± 0.62 cm. Progressing further to 70 DAT, GR-15 had the smallest mean leaf width of 13.54± 0.35 cm, whereas TN-1 had the largest mean width of 17.19± 0.14 cm. At 80 DAT, GNR-6 exhibited the smallest mean leaf width of 14.21± 1.80cm, and TN-1 had the largest mean width of 17.25± 0.81cm. The trend continued with GR-15 having the smallest mean leaf width at 90 DAT, and TN-1 having the largest mean width at 100 DAT, GNR-7 showed the smallest mean leaf width of 14.72± 0.56cm, while TN-1 had the largest mean width of 17.91± 0.41cm. Finally, at 110 DAT, GNR-6 had the smallest mean leaf width of 14.97± 1.74cm, and TN-1 had the largest mean width of 17.96± 0.98cm. The data revealed a significant positive correlation between leaf width and the infestation (Table 2). This finding is consistent with previous studies by Rautaray (2021), Konni (2016), and Kamshki (2012).

The data on chlorophyll contents during the initial and peak infestation at 30 and 50 DAT is presented in Table 3. The mean chlorophyll content ranged from 35.63± 2.72 to 44.03± 1.21 (SPAD value). The minimum chlorophyll content was recorded at 35.63± 2.72 in GR-15. Whereas, the maximum chlorophyll content was recorded at 44.03± 1.21 in TN-1. At 50 DAT, the mean chlorophyll content was ranged from 47.76± 1.32 to 53.66± 0.99. The minimum chlorophyll content was recorded at 47.76± 1.32 in GR-15. Whereas, the maximum chlorophyll content was recorded at 53.66± 0.99 in TN-1. The chlorophyll content had a significant positive correlation with infestation (Table 2). Similarly, Kamakshi (2012) reported that the highest chlorophyll content was 43.7 in the leaves of NLR33671-7, and in NLR 40059 it was found to be the lowest (35.10 SPAD value). Total phenol content during the early and peak stages of infestation is shown in Table 3. The lowest phenol content was observed in TN-1 at 2.36± 0.22mg/ g, while the highest was in GR-15 at 4.10± 0.18 mg/ g. Interestingly, there was a significant negative correlation between total phenol content and *C. medinalis* infestation (Table 2). This aligns with Kumar et al. (2021) and Ashrith et al. (2020).

Total sugar content ranged from 13.14± 0.43% to 18.26± 1.26%. The lowest sugar content of 13.14± 0.43% was recorded in GR-15, while the highest sugar content of 18.26± 1.26% was found in TN-1. By the time 50 DAT was reached, the sugar content ranged from 3.45± 0.59% to 9.10± 0.69%. Once again, GR-15 had the lowest sugar content at 3.45± 0.59%, while TN-1 had the highest at 9.10± 0.69%. It was observed that there was a positive correlation between the total sugar content and infestation. Kumar et al. (2021) revealed that the total sugar content under infested conditions was significantly less in the highly resistant varieties. The protein content ranged from 6.34± 0.10 to 12.68± 0.19 mg/ 100g; lowest was found to be 6.34± 0.10 mg/ 100g in GR-15, while the highest was recorded at 12.68± 0.19 mg/ 100g in TN-1. It showed a significant positive correlation with infestation (Table 2). Kumar et al. (2021) concluded that the total protein content was significantly lower in highly resistant varieties. Ashrith et al. (2020) reported that the leaf protein had a positive correlation with infestation.

Table 1. Length and width of rice leaf at different days interval

Sr. No.	Treatment	Length of leaf (mm)									Width of leaf (mm)								
		30 DAT	40 DAT	50 DAT	60 DAT	70 DAT	80 DAT	90 DAT	100 DAT	110 DAT	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT	80 DAT	90 DAT	100 DAT	110 DAT
1	NAUR-1	26.91 ±0.54	28.69 ±0.70	32.63 ±0.93	35.27 ±1.74	38.25 ±1.14	43.13 ±1.59	45.99 ±1.30	47.82 ±0.69	48.12 ±0.49	11.14 ±0.87	12.17 ±1.44	13.48 ±0.95	14.62 ±1.04	15.71 ±1.27	15.74 ±0.96	16.07 ±1.00	16.34 ±1.10	16.88 ±0.88
2	GNR-2	26.53 ±0.64	29.19 ±0.75	32.67 ±0.78	34.95 ±1.18	38.36 ±0.77	43.00 ±1.58	45.90 ±1.29	47.25 ±0.91	47.40 ±0.89	10.25 ±0.60	11.43 ±0.67	13.33 ±1.17	13.88 ±0.30	13.99 ±0.93	15.33 ±1.16	17.02 ±0.98	17.23 ±1.03	17.26 ±0.35
3	GNR-3	25.54 ±0.52	28.22 ±1.17	32.46 ±0.94	35.10 ±0.42	37.80 ±0.32	43.01 ±1.61	45.51 ±1.00	47.08 ±0.38	47.17 ±0.38	10.93 ±1.07	12.95 ±0.80	13.82 ±0.36	14.64 ±0.42	14.89 ±0.31	15.02 ±0.55	15.68 ±1.61	15.76” ±0.60	15.90 ±1.35
4	GNR-4	26.82 ±0.72	28.76 ±1.06	32.70 ±0.91	35.67 ±0.76	38.51 ±0.86	44.30 ±0.82	46.75 ±0.91	47.95 ±0.68	48.00 ±0.68	11.59 ±1.13	12.96 ±1.48	13.74 ±0.27	15.47 ±0.62	16.05 ±1.44	16.21 ±0.99	17.36 ±0.76	17.33 ±0.14	17.42 ±0.91
5	GNR-5	26.34” ±0.69	28.35 ±0.43	32.61 ±0.80	34.62 ±0.93	37.42 ±0.91	42.82 ±1.40	45.78 ±1.33	46.98 ±0.78	47.13 ±0.70	11.00 ±0.88	12.61 ±1.36	13.79 ±0.50	14.39 ±0.45	14.99 ±0.59	15.20 ±1.54	15.56 ±1.10	15.67 ±1.06	16.90 ±1.16
6	GNR-6	26.01 ±0.71	28.05 ±0.60	32.63 ±0.99	34.38 ±0.90	38.33 ±0.70	43.32 ±0.74	45.62 ±1.32	46.87 ±0.72	46.96 ±0.71	10.74 ±0.25	12.52 ±1.10	13.08 ±0.22	13.38 ±0.72	14.11 ±0.95	14.21 ±1.04	14.55 ±1.35	14.74 ±1.05	14.97 ±1.74
7	GNR-7	25.70 ±0.76	28.00 ±0.83	32.02 ±1.39	34.46 ±1.01	39.61 ±0.45	44.79 ±0.47	47.87 ±0.42	49.49 ±0.67	49.53 ±0.66	10.76 ±1.28	11.55 ±0.38	12.91 ±0.85	13.44 ±1.25	13.59 ±1.24	13.65 ±0.77	14.64 ±0.98	14.72 ±0.56	14.98 ±0.65
8	GR-15	27.30 ±0.71	29.08 ±0.77	33.22 ±0.39	35.74 ±0.90	39.86 ±0.33	45.03 ±0.39	48.10 ±0.76	49.08 ±0.60	49.14 ±0.59	10.95 ±0.95	11.78 ±1.11	12.79 ±1.13	13.36 ±0.92	13.54 ±0.35	14.35 ±1.08	15.47 ±1.62	16.10 ±0.71	16.37 ±0.62
9	GR-11	25.37 ±0.46	27.77 ±0.49	30.58 ±0.93	34.13 ±0.93	37.48 ±0.87	42.27 ±1.39	45.27 ±1.01	46.79 ±0.40	46.91 ±0.38	11.30 ±1.06	13.07 ±1.19	13.76 ±1.08	14.84 ±0.25	14.95 ±0.97	15.38 ±0.54	16.38 ±0.74	17.08 ±0.92	17.70 ±0.95
10	TN-1	26.91 ±0.54	28.66 ±0.91	32.69 ±0.73	34.95 ±0.55	37.58 ±0.72	42.34 ±1.68	45.39 ±1.01	46.55 ±0.54	46.72 ±0.36	12.04 ±0.90	14.22 ±0.95	14.33 ±1.17	15.42 ±1.03	17.19 ±0.14	17.25 ±0.81	17.66 ±0.89	17.91 ±0.41	17.96 ±0.98

Table 2. Correlation coefficient-infestation of *C. medinalis* vs. morpho-biochemical parameters (n=10)

Sr. No.	Parameters	Correlation coefficient								
		30 DAT	40 DAT	50 DAT	60 DAT	70 DAT	80 DAT	90 DAT	100 DAT	110 DAT
1.	Leaf thickness	-0.16	-0.31	-0.35	-0.26	-0.27	-0.46	-0.30	-0.46	-0.38
2.	Leaf length	-0.24	-0.16	-0.55	-0.25	-0.51	-0.55	-0.46	-0.46	-0.47
3.	Leaf width	0.71*	0.64*	0.65*	0.66*	0.69*	0.74*	0.65*	0.71*	0.70*
4.	Chlorophyll content	0.78**	--	0.81**	--	--	--	--	--	--
5.	Phenol content	-0.84**	--	-0.84**	--	--	--	--		--
6.	Total sugar content	0.76*	--	0.75*	--	--	--	--		
7.	Total protein content	0.95**	--	0.96**	--	--	--	--		

*Significant p= 0.05; ** Significant at 0.01

Table 3. Biochemical traits of rice vs. *C. medinalis* infestation

Sr. No.	Treatments	Chlorophyll content		Phenol content		Sugar content		Protein content	
		30 DAT	50 DAT	30 DAT	50 DAT	30 DAT	50 DAT	30 DAT	50 DAT
1	NAUR-1	41.52± 1.89	51.21± 0.93	3.00± 0.41	4.68± 0.54	16.06± 0.36	7.52± 0.22	9.34± 0.62	18.74± 0.81
2	GNR-2	40.18± 0.54	49.88± 0.71	3.70± 0.34	5.74± 1.41	15.51± 0.61	6.89± 0.45	7.81± 0.14	14.89± 0.47
3	GNR-3	37.70± 1.53	49.62± 1.00	3.87± 0.30	5.08± 0.53	14.33± 0.83	4.98± 0.88	7.11± 0.29	14.15± 0.71
4	GNR-4	41.69± 0.88	51.66± 1.66	2.94± 0.72	4.30± 0.13	17.93± 1.59	7.92± 0.73	9.51± 0.46	17.40± 0.44
5	GNR-5	39.47± 0.89	50.84± 0.86	3.37± 0.87	5.30± 0.43	15.00± 0.29	5.82± 0.09	7.75± 0.25	14.51± 0.26
6	GNR-6	36.46± 0.12	48.83± 0.88	3.63± 0.37	5.53± 1.04	14.72± 0.14	5.06± 0.68	7.30± 0.53	14.51± 0.31
7	GNR-7	35.90± 1.54	48.63± 1.26	4.04± 0.22	5.84± 0.39	13.66± 0.31	3.53± 0.16	6.96± 0.67	14.05± 0.82
8	GR-15	35.63± 2.72	47.76± 1.32	4.10± 0.18	6.26± 0.53	13.14± 0.43	3.45± 0.59	6.34± 0.10	13.39± 0.06
9	GR-11	42.72± 1.27	52.01± 1.12	2.76± 0.22	4.02± 0.43	17.11± 0.28	8.06± 0.68	11.94± 0.44	22.75± 1.54
10	TN-1	44.03± 1.21	53.66± 0.99	2.36± 0.22	3.76± 0.64	18.26± 1.26	9.10± 0.69	12.68± 0.19	23.76± 1.78

There is a strong positive relationship between leaf width and infestation and also as regards levels of chlorophyll, sugar, and protein. On the other hand, the phenol content displayed a significant negative correlation. It is suggested that enhancing the resistance of a plant variety against *C. medinalis* may be achieved by reducing the leaf width and phenol content through the deactivation of specific genes. Furthermore, increasing the levels of chlorophyll, sugar, and protein may be achieved by incorporating genetic material from wild sources.

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AUTHOR CONTRIBUTION STATEMENT

KLB conducted the research, PDG supervised the work, MKJ wrote, reviewed, and edited the manuscript.

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CONFLICT OF INTEREST

No conflict of interest.

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