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Biochemical changes in susceptible and resistant rice varieties due to infection by *Meloidogyne graminicola* Golden and Birchfield

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ABSTRACT

Biochemical changes in rice varieties Annapurna, Manika and Ramakrishna showing susceptible, moderately resistant and resistant reactions, respectively to the root knot nematode Meloidogyne graminicola were studied six weeks after inoculating the plants with the nematode @ 1000 J_2 plant^{-1}. Chlorophyll content decreased by 60.7, 24.9 and 1%; root sugar increased by 43.8, 17.7 and 10.7%; shoot sugar decreased by 26.5, 28.8 and 10.8%; root nitrogen and protein increased by 27.1, 30.4 and 4.3%; shoot nitrogen and protein decreased by 22, 16.6 and 2.4%; root phosphorus decreased by 34.8, 9.8 and 10.6%; shoot P decreased by 25.2, 6.7 and 1%; root potassium decreased by 16.5, 56.% and 73.1%; shoot K decreased by 59.6, 18.9 and 22.7%, respectively in the test varieties.

Key words: *Meloidogyne graminicola, infection, rice, biochemical changes*

Root knot nematode *Meloidogyne graminicola* golden and birchfield is the most important nematode pest of rice causing heavy loss to this crop in uplands. It is also reported to be a threat to wheat crop in the irrigated tracts in North and North West India (Gaur *et al*., 1996). Three rice varieties viz. Ramakrishna, Rasi and Kalarata have been found to be resistant to this nematode (Bose *et al*, 1998). An attempt was made to correlate the biochemical changes in different plant parts of rice plants varying degree of resistance when inoculated with *M. graminicola*.

MATERIALS AND METHODS

The nematode population was derived from a single egg mass progeny, maintained on rice plants, var. Annapurna in pots containing steam sterilized soil. For testing the parameters 20 cm earthen pots were filled with sterilized soil and sand mixture in equal proportions. Surface sterilized seeds of resistant var. Ramakrishna, moderately resistant Manika and the susceptible check Annapurna were sown @ 10 seeds in the pots. Seven days after germination these were thinned to three seedlings per pot. On the 15th day J_2 of *M. graminicola* nematode were inoculated into soil at the plant base @ 1000 plant^{-1}. Six weeks after inoculation plants were taken for observing different biochemical parameters. Estimation of each parameter was replicated 4 times in a CRD design, analyzed statistically and compared with the non inoculated check.

Chlorophyll was extracted from plant leaves in 80% acetone and observed at 645 nm and 663 nm in a spectrophotometer to estimate chlorophyll a, b and total fractions. Both root and shoot samples from infected and healthy plants of these varieties were collected, oven dried and powdered to estimate the sugar, protein, N, P and K contents. Analysis was done as per the methods described by Mahadevan and Sreedhar, 1986.

RESULTS AND DISCUSSION

Due to the nematode infection chlorophyll a was reduced from 2.367 mg g^{-1} to 0.812 mg g^{-1} in Annapurna; 2.349 to 1.719 mg g^{-1} in Manika and 2.117 to 2.097 mg g^{-1} in Ramakrishna, which accounted for reductions of 65.7, 26.8 and 1% respectively in these varieties. After computing chlorophyll b fraction it was observed that the total chlorophyll in the leaves got reduced by 60.7% in Annapurna, 24.9% in Manika and 1% in Ramakrishna (Table 1). This indicates that nematode infection causes nutrient shortage, which triggers depletion of chlorophyll, which in turn reduces

Table 1. Chlorophyll content in rice leaves as influenced by *M. graminicola*

Variety	Chlorophyll a content (mg g^{-1})			Chlorophyll b content (mg g^{-1})			Total Chlorophyll (mg g^{-1})		
	Healthy	Infected	(%) decrease	Healthy	Infected	%decrease	Healthy	Infected	%decrease
Annapurna	2.367	0.812	65.7	0.982	0.504	48.6	3.349	1.316	60.7
Manika	2.349	1.719	26.8	0.974	0.775	20.4	3.323	2.494	24.9
Ramakrishna	2.117	2.097	1.0	0.98	0.972	1.0	3.097	3.069	1.0
CD (P=0.05)	0.051	0.042	-	0.013	0.104	-	0.049	0.040	-

carbon assimilation and successive metabolic processes. As more assimilates are consumed in the giant cells by the nematode they are transported from shoot to the root on priority basis, causing reduction in several nutrients, thus reducing total biomass (Rao *et al*., 1986). In a few cases, particularly in resistant varieties, chlorophyll content was found to increase after nematode infection (Swain and Prasad, 1988).

There were 43.8, 17.7 and 10.7% increase in root sugar in the nematode infected plants of Annapurna, Manika and Ramakrishna, respectively over their healthy counterparts, where as reductions of 26.5, 28.8 and 10.8% were recorded in the shoot portion of these varieties (Table 2). Sugar production might have been reduced due to reduction in leaf chlorophyll content, which is expressed in the shoot. Thus phenomenos was been recorded by earlier workers (Rao *et al.*, 1988 and Mohanty *et al*., 1997). But its increase in root signifies that the metabolically active giant cells demand greater amount of energy which the plant supplies by converting the stored starch in the shoot to sugar and then transporting it to root.

Healthy roots of varieties Annapurna, Manika and Ramakrishna contained 1.44, 1.51 and 1.17% of nitrogen respectively on dry wt. basis. Due to root knot infection it increased by 27.1% in Annapurna and 30.4% in Manika and only 4.3% in Ramakrishna, (Table 3). These findings are in agreement with that of Ganguly and Dasgupta (1983) and Mohanty *et al*. (1997) in other crops. Similarly, the shoot N content was 1.73, 1.64 and 1.72% in the varieties Annapurna, Manika and Ramakrishna, respectively in healthy plants. They decreased by 22, 16.6 and 2.4% respectively in the root knot infected plants.

Protein content of the healthy roots measured 9% in Annapurna, 9.43% in Manika and 7.31% in Ramakrishna. Due to nematode infection it increased 27.1% in Annapurna, 30.4% in Manika and 4.3% in Ramakrishna. The shoot protein decreased by 22, 16.6 and 2.4% in Annapurna, Manika and Ramakrishna respectively (Table 4). The decrease was not significant in the resistant variety. Nutrient accumulation in the nematode infected roots was possibly due to impaired translocation of the minerals to aerial parts and mobilization of food matter from shoot to roots to nourish the galls, the process being more pronounced in the susceptible variety. When the plant is in a declining stage the enzyme Ribulose 1-5 diphosphate carboxylase (RUBISCO), which accounts for a huge chunk of the protein N in the leaves is broken down to simpler proteins and gets translocated. Furthermore, chlorophyll itself is broken down, there by reducing the shoot protein amount (Jena and Rao, 1977; Ganguly *et al*., 1991).

Healthy plant roots of the varieties Annapurna, Manika and Ramakrishna contained 0.215, 0.214 and 0.179% phosphorus, respectively (Table 5). The amounts of P in the former two were significantlly higher than that in Ramakrishna. Phosphorus content decreased in all the varieties due to root knot infection. The reductions were 34.8, 9.8 and 10.6%, respectively in the varieties nnapurna, Manika and Ramakrishna. Phosphorus content in the shoot measured 0.293, 0.269 and 0.22% respectively. Due to nematode infection P content of shoot decreased by 25.2, 6.7 and 1% in these varieties. Phosphorus acts as the energy transfer agent changing from ATP to ADP and vice versa, regulating metabolic activities of the plant. Hence reduction in P content indicates general reduction in cell activity, both in root and shoot, excepting the galls (Rao *et al*., 1986). Contrary to this observation, Hunter (1958) and Chakrabarti and Mishra, (2002) have recorded increase in root P content in some crops infected with *M. incognita*.

Potassium content in the healthy, dried roots measured 0.965, 1.105 and 1.34%, respectively in Annapurna, Manika and Ramakrishna. Due to infection they decreased by 16.5, 56.1 and 73.1%, respectively in these varieties (Table 6). The decrease was greater in the resistant variety than the susceptible. In the healthy plants K content of the shoot was found to be 4.225% in Annapurna, 3.517% in Manika and 2.465% in Ramakrishna which reduced by 59.6, 18.9 and 22.7%

Table 2. Total sugar content in the roots and shoots of rice varieties as influenced by *M. graminicola*

Variety	Sugar content in root (% fresh wt.)			Sugar content in shoot (% fresh wt.)		
	Healthy	Infected	% increase	Healthy	Infected	% decrease
Annapurna	0.343	0.493	43.8	1.57	1.15	26.5
Manika	0.399	0.471	17.7	1.44	1.03	28.8
Ramakrishna	0.463	0.513	10.7	1.58	1.41	10.8
CD (P=0.05)	0.041	0.033	-	0.063	0.052	-

Table 3. Nitrogen content of roots and shoots of rice varieties as influenced by *M. graminicola*

Variety	Nitrogen content in root (% dry wt.)			Nitrogen content in shoot (% dry wt.)		
	Healthy	Infected	% increase	Healthy	Infected	% decrease
Annapurna	1.44	1.83	27.1	1.73	1.35	22.0
Manika	1.51	1.97	30.4	1.64	1.37	16.6
Ramakrishna	1.17	1.22	4.3	1.72	1.68	2.4
CD (P=0.05)	0.104	0.085	-	0.101	0.082	-

Table 4. Influence of *M. graminicola* on the crude protein content of roots and shoots of rice varieties

Variety	Protein content in root (% dry wt.)			Protein content in shoot (% dry wt.)		
	Healthy	Infected	% increase	Healthy	Infected	% decrease
Annapurna	9.0	11.43	27.1	10.81	8.43	22
Manika	9.43	12.31	30.4	10.25	8.56	16.6
Ramakrishna	7.31	7.62	4.3	10.75	10.5	2.4
CD (P=0.05)	0.652	0.531	-	0.631	0.512	-

Table 5. Effect of *M. graminicola* on phosphorus content in the roots and shoots of rice varieties

Variety	Phosphorus content in root (% dry wt.)			Phosphorus content in shoot (% dry wt.)		
	Healthy	Infected	% decrease	Healthy	Infected	% decrease
Annapurna	0.215	0.14	34.8	0.293	0.219	25.2
Manika	0.214	0.193	9.8	0.269	0.251	6.7
Ramakrishna	0.179	0.16	10.6	0.220	0.218	1.0
CD (P=0.05)	0.0133	0.0108	-	0.0152	0.0123	-

Table 6. Potassium content in the root and shoot of rice varieties as influenced by *M. graminicola*

Variety	Potassium content in root (% dry wt.)			Potassium content in shoot (% dry wt.)		
	Healthy	Infected	% decrease	Healthy	Infected	% decrease
Annapurna	0.965	0.805	16.5	4.225	1.705	59.6
Manika	1.105	0.485	56.1	3.517	2.85	18.9
Ramakrishna	1.34	0.36	73.1	2.465	1.905	22.7
CD (P=0.05)	0.074	0.061	-	0.069	0.565	-

respectively in the infected plants. This reduction was highly significant in all three varieties. Chakrabarti and Mishra (2002) have also recorded decrease in K content of the root due to root knot infection in chickpea, but conversely there the extent of reduction of K was less in the resistant variety.

Infection of root knot nematode causes a lot of biochemical changes in the infected cells and in the plant system. The changes are very much discernible when compared with relatively susceptible and resistant varieties as the latter does not show much change due to infection. Therefore these parameters can be observed in order to distinguish between susceptible and resistant varieties during screening of varieties against the nematode pest.

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