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Physiological Alterations Induced by Plant Extracts in Rice Plants Inoculated with *Sarocladium Oryzae*

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The contents of total soluble, reducing and non-reducing sugars decreased in rice plants due to infection by *S. oryzae.* But the extent of reduction in plants treated with botanicals followed by inoculation was significantly less. The total soluble and reducing sugar content significantly increased by the spraying of botanicals. The maximum increase being in plants sprayed with the leaf extracts of *Acacia leucophloea* and *Phyllanthus niruri.* The maximum reduction of total soluble and reducing sugars was recorded in the case of *P. niruri* treated plus pathogen inoculated plants. The maximum increase in non-reducing sugars was observed in the plants sprayed with the leaf extracts of *Euphorbia hirta* and *Pongamia glabra.* Plants sprayed with *P. niruri* leaf extract plus inoculation of the pathogen recorded the highest reduction in non-reducing sugar content. In rice plants the highest total phenol content was observed in the plants seven days after inoculation and their content reduced with lapse of time. Spraying of plant products followed by inoculation tremendously increased the total phenols as compared to the plants sprayed with plant products alone (without pathogen inoculation). The total phenol content increased to the maximum extent of 25.50 per cent in the plants sprayed with neem oil followed neem seed kernel extract and leaf extracts of *C. arvensis, A. indica, C. roseus* and *O. tenuiflorum* plus pathogen inoculation recording 24.88, 21.41, 21.04, 20.67 and 20.05 per cent increase respectively. The total protein content of the inoculated rice plants increased more with increase (18.39%) in the age of plants. Spraying of plant products resulted in remarkable increase in protein content and the maximum being 27.25 per cent in the plants sprayed with neem seed kernel extract. Plant products treated plus inoculation of the pathogen had resulted in less protein content of the rice plants as compared to plant products treatment alone without inoculation of the pathogen.

Keywords: Rice sheath rot, plant extracts, physiological effects.

Sheath rot disease of rice, although is known to occur in many South East Asian countries since several decades, has assumed serious proportions in the recent years in India inflicting considerable losses on many rice cultivars. Eswaran (1990) observed that the content of total phenols and O.D. phenols considerably increased in rice plants sprayed with carbendazim (0.25%) spray before inoculation of sheath rot pathogen. There was slight reduction in total phenol and O.D. phenol content in plants sprayed with plant extracts *viz., Adathoda vasica* Nees, *Cocos nucifera* (L.) Nees and *Eucalyptus globulus* Labill. before inoculation. Selvaraj (1990) reported that, the sugar fractions showed reduction in sheath rot inoculated and healthy plants. Phenol content increased to higher levels in plants sprayed with plant extracts *viz., Tribulus terrestris* L., *Catharanthus roseus* (L.) G.Don. and *Ocimum tenuiflorum* L. and chemicals, acridine orange and barium chloride than in the *S. oryzae* inoculated and healthy rice plants. Significant increase in protein contents was observed in the inoculated plants over treated and healthy plants.

Materials and Methods

The treatments *viz.,* leaf extracts (10%) of *A. indica, O. tenuiflorum, C. arvensis, C. roseus, D. stramonium,* C. *martini, I. carnea, P. dulce, B. spectabilis, V. negundo* var. *purpurascense, Q. indica, E. globulus, P. emblica, T. peruviana, E. hirta, P. hysterophorus, P. longifolia, T. divaricata, C. longa, A. leucophloea, P. glabra,* and *P. niruri*; neem oil(3%) and neem seed kernel extract (5%) were sprayed on 85- day -old CO 43 rice plants and these plants were inoculated with *Sarocladium oryzae* by single grain culture insertion method at 24 h after spraying. Similarly another set of plants kept as control were given these treatments but without inoculation of the pathogen. The plant tissue analyses for sugars, total phenols and total protein were carried out 7, 14 and 21 days after inoculation. For this, the leaf sheath samples were collected and the tissue analysis was

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done separately for each treatment. Three replications were maintained for each treatment. Suitable control was also maintained.

Estimation of sugars

Extraction of plant tissues in alcohol

A quantity of 100mg of the leaf sheath sample was chopped into small bits and plunged into 10ml of boiling 80 per cent ethanol for five to 10 min. The extract was cooled and the tissues were crushed in a pestle and mortar. The ground tissue was passed through two layered cheese cloth and re-extracted the ground tissues in two to three ml of boiling 80 per cent ethanol for three min to ensure complete removal of alcohol-soluble substances. Both the extracts were mixed and filtered through a What man No.41 filter paper and the volume was made upto 10ml with 80 per cent ethanol or reduced the volume of the extract to 10ml by evaporating it in a boiling water bath.

Total soluble sugars

Total soluble sugars were estimated by the method described by Dubois *et al.* (1951). In a graduated test tube, one ml of ethanol extract was pipetted out and four ml of fresh anthrone reagent was added along the side of the test tube. The tube was placed in a boiling water bath for 10 min and cooled down in running tap water. Reagent blank was maintained with one ml of distilled water instead of the ethanol extract. The intensity of colour (blue-green) was read at 625nm in a colorimeter. Glucose was used as the standard.

Reducing sugars

Reducing sugars were estimated by the Nelson's method (Nelson, 1944). In a graduated test tube, one ml of ethanol extract and one ml of fresh Nelson reagent were added, mixed well and boiled for 20 min in a hot water bath. The tube was cooled in running tap water and one ml of arsenomolybdate reagent was added. After 15 min, the contents were made upto 25ml with distilled water and the blue colour was read in a colorimeter at 500nm. Reagent blank was maintained with one ml of distilled water instead of the test material. The amount of reducing sugars was calculated from a standard curve drawn with different concentrations of glucose.

Non-reducing sugars

The quantity of non-reducing sugars was calculated by deducting the reducing sugar content from that of the total soluble sugars.

Estimation of total phenols

Total phenol content of the leaf sheath samples was estimated by Folin-Ciocalteu method (Bray and Thorpe, 1954). One gram of the fresh leaf sheath sample was chopped into small bits and plunged into 10 ml of boiling 80 per cent ethanol for five to 10 min. The extract was cooled and the tissues were crushed in a pestle and mortar, then passed through two layered cheese cloth and re-extracted the ground tissues in two to three ml of boiling 80 per cent ethanol for three minutes. Both the extracts were mixed and filtered through a Whatman No.41 filter paper and the volume was made upto 10 ml with 80 per cent ethanol or reduced the volume of the extract to 10 ml by evaporating it in a boiling water bath.

In a graduated test tube, one ml of ethanol extract, one ml of Folin-Ciocalteu reagent and two ml of 20 per cent sodium carbonate solution were added and the mixture was heated in a boiling water bath for exactly one min. The tube was cooled in running tap water. The volume was made up to 25 ml with distilled water. Reagent blank was maintained with one ml of distilled water instead of the leaf sheath extract.The intensity of the colour was read at 650 nm in a colorimeter. The amount of total phenols present in the sample was calculated from a standard curve prepared by using different concentrations of catechol.

Estimation of total protein (Lowry et al., *1951)*

One gram of the leaf sheath sample was homogenized with 10ml of phosphate buffer (pH 7.0). The homogenized solution was centrifuged and 0.1 ml of the supernatant solution was taken in a test tube, the volume was made up to one ml with distilled water and five ml of alkaline copper solution were added. After 10 min, 0.5 ml of Folin-Ciocalteu reagent was added and mixed well. Reagent blank was maintained with one ml of distilled water instead of the sample extract. The colour (blue) was read after 30 min at 660 nm in a spectrophotometer. The bovine serum albumin solution was used to obtain the standard graph. From the standard graph, the amount of protein present in the sample was calculated.

Results and Discussion

Total soluble sugars

Healthy rice plants showed increased total soluble sugar content progressively with increase in the age of the plants, but it was drastically reduced by 26.73 per cent in the plants artificially inoculated with *S. oryzae*. It increased by the application of leaf extracts (10%) and the maximum (7.13%) increase was in the case of *Acacia leucophloea* followed by *Phyllanthus niruri* (7.10%) and *Pongamia glabra* (7.05%). The minimum (2.95%) increase was recorded in the rice plants sprayed with neem oil (3%). The maximum (22.91%) reduction of total soluble sugars was recorded in 10 per cent *P. niruri* treated and inoculated plants. It was next only to inoculated plants without any plant product treatment. The minimum reduction (12.07%) of total soluble sugars was registered in neem oil (3%) treated and inoculated plants followed by five per cent neem seed kernel extract treated and inoculated

Table 1. Effect of plant extracts on total soluble sugars of Co 43 rice plants

Plant extracts	Total soluble sugars (mg/g)*				Total soluble sugars increase (+) or decrease (-) (%)*
	Days after inoculation				
	7	14	21	Mean	
Neem oil - 3% T	19.563	21.824	22.208	21.198	+ 2.95
Neem oil –3% T and I	19.040	18.123	17.152	18.105	- 12.07
Neem seed kernel extract-5% T	19.680	21.867	22.229	21.259	+ 3.25
Neem seed kernel extract-5% T and I	19.019	18.069	17.056	18.048	- 12.35
Acalypha indica T	19.893	22.016	22.688	21.532	+ 4.58
A.indica T and I	18.827	17.579	16.629	17.678	- 14.14
Ocimum tenuiflorum T	19.957	22.037	22.699	21.564	+ 4.73
O. tenuiflorum T and I	18.784	17.536	16.203	17.508	- 14.97
Convolvulus arvensis T	19.925	22.251	22.485	21.554	+ 4.68
C. arvensis T and I	18.816	17.568	16.544	17.643	- 14.31
Catharanthus roseus T	20.032	22.016	22.699	21.582	+ 4.82
C. roseus T and I	18.805	17.557	16.384	17.582	- 14.61
Datura stramonium T	20.213	22.091	22.699	21.668	+ 5.24
D. stramonium T and I	17.653	16.832	15.968	16.818	- 18.32
Cymbopogon martini T	20.032	22.101	22.880	21.671	+ 5.25
C. martini T and I	17.931	16.779	15.595	16.768	- 18.56
Ipomoea carnea T	20.352	22.176	22.816	21.781	+ 5.78
I . carnea T and I	17.739	16.981	15.115	16.612	- 19.32
Pithecolobium dulce T	20.245	22.176	23.200	21.874	+ 6.24
P.dulce T and I	17.429	16.747	15.680	16.619	- 19.29
Bougainvillaea spectabilis T	20.213	22.101	23.179	21.831	+ 6.03
B. spectabilis T and I	17.536	16.939	15.584	16.686	- 18.96
Vitex negundo var. *purpurascense* T	20.149	22.069	22.997	21.738	+ 5.58
V. negundo var. *purpurascense* T and I	17.877	16.736	15.584	16.732	- 18.74
Quisqualis indica T	20.533	22.240	23.019	21.931	+6.51
Q. indica T and I	17.781	16.832	14.635	16.416	- 20.27
Eucalyptus globules T	20.235	22.112	23.232	21.860	+ 6.17
E. globulus T and I	17.323	16.789	15.520	16.544	- 19.65
Phyllanthus emblica T	20.352	22.080	23.339	21.924	+ 6.48
P. emblica T and I	17.024	16.736	15.477	16.412	- 20.29
Thevetia peruviana T	20.235	22.208	23.200	21.881	+ 6.27
T. peruviana T and I	17.653	16.629	15.104	16.462	- 20.05
Euphorbia hirta T	20.427	22.133	23.424	21.995	+ 6.82
E.hirta T and I	17.024	16.384	15.296	16.235	- 21.15
Parthenium hysterophorus T	20.480	22.144	23.200	21.941	+ 6.56
P. hysterophorus T and I	17.035	16.565	14.997	16.199	- 21.33
Polyalthia longifolia T	20.416	22.133	23.253	21.934	+ 6.53
P. longifolia T and I	17.525	16.875	14.688	16.363	- 20.53
Tabernaemontana divaricata T	20.683	22.283	22.933	21.966	+ 6.68
T. divaricata T and I	16.971	16.384	14.955	16.103	- 21.79
Curcuma longa T	20.320	22.144	23.467	21.977	+ 6.74
C. longa T and I	16.981	16.032	15.019	16.011	- 22.24
Acacia leucophloea T	20.853	22.123	23.200	22.059	+ 7.13
A. leucophloea T and I	16.981	15.861	14.997	15.946	- 22.55
Pongamia glabra T	21.035	22.325	22.763	22.041	+ 7.05
P. glabra T and I	16.789	15.851	15.093	15.911	- 22.72
Phyllanthus niruri T	21.003	22.101	23.051	22.052	+ 7.10
P. niruri T and I	16.789	15.882	14.944	15.872	- 22.91
Inoculated	16.213	15.424	13.621	15.086	- 26.73
Healthy	19.019	20.928	21.824	20.590	0.00
	Mean	18.948	19.427	19.210	
T-Treated I-Inoculate	CD (P = 0.05)				
* Mean of three replications	Treatment : 0.177				
	Days : 0.043				
	TxD : 0.306				

plants (12.35%). In case of plant products treated uninoculated, the total soluble sugar content progressively increased with increase in the age of the plants, while in plant products treated and inoculated plants, it decreased with the increase in days after inoculation. The maximum (23.467mg/g) total soluble sugar content was recorded in *C. longa* leaf extracts (10%) treated plants 21days after treatment followed by *E. hirta* treated plants (23.424mg/g) and these were on par (Table 1).

Table 2. Effect of plant extracts on reducing sugars of Co 43 rice plants

Plant extracts	Reducing sugars (mg/g)*				Reducing sugars increase (+) or decrease (-) (%)*
	Days after inoculation				
	7	14	21	Mean	
Neem oil – 3% T	11.440	12.008	12.552	12.000	+ 2.39
Neem oil –3% T and I	11.048	10.040	9.136	10.075	- 14.04
Neem seed kernel extract-5% T	11.488	12.064	12.560	12.037	+2.70
Neem seed kernel extract-5% T and I	11.016	10.008	9.024	10.016	- 14.54
Acalypha indica T	11.568	12.216	12.680	12.155	+ 3.71
A.indica T and I	10.944	9.872	8.568	9.795	- 16.42
Ocimum tenuiflorum T	11.536	12.272	12.744	12.184	+ 3.96
O. tenuiflorum T and I	10.896	9.832	8.552	9.760	- 16.72
Convolvulus arvensis T	11.608	12.248	12.656	12.171	+ 3.85
C. arvensis T and I	10.952	9.904	8.560	9.805	- 16.34
Catharanthus roseus T	11.552	12.200	12.648	12.133	+ 3.52
C. roseus T and I	10.824	9.896	8.632	9.784	- 16.52
Datura stramonium T	11.616	12.320	12.856	12.264	+ 4.64
D. stramonium T and I	10.640	9.312	8.408	9.453	- 19.34
Cymbopogon martini T	11.680	12.216	12.752	12.216	+ 4.23
C. martini T and I	10.784	9.280	8.216	9.427	- 19.56
Ipomoea carnea T	11.744	12.328	12.824	12.299	+ 4.94
I . carnea T and I	10.696	9.064	8.184	9.315	- 20.52
Pithecolobium dulce T	11.808	12.368	12.904	12.360	+ 5.46
P.dulce T and I	10.432	9.304	8.320	9.352	- 20.20
Bougainvillaea spectabilis T	11.760	12.352	12.904	12.339	+ 5.28
B. spectabilis T and I	10.480	9.416	8.256	9.384	- 19.93
Vitex negundo var. *purpurascense* T	11.736	12.312	12.808	12.285	+ 4.82
V. negundo var. *purpurascense* T and I	10.584	9.336	8.304	9.408	- 19.73
Quisqualis indica T	11.904	12.384	12.920	12.403	+ 5.83
Q. indica T and I	9.968	9.280	8.296	9.181	- 21.66
Eucalyptus globulus T	11.736	12.384	12.920	12.347	+ 5.35
E. globulus T and I	10.592	9.040	8.304	9.312	- 20.55
Phyllanthus emblica T	11.840	12.400	12.928	12.389	+ 5.71
P. emblica T and I	10.024	9.280	8.208	9.171	- 21.75
Thevetia peruviana T	11.896	12.360	12.936	12.397	+ 5.78
T. peruviana T and I	10.136	9.240	8.160	9.179	- 21.68
Euphorbia hirta T	11.896	12.360	13.024	12.427	+ 6.03
E.hirta T and I	9.904	9.048	8.080	9.011	- 23.11
Parthenium hysterophorus T	11.808	12.384	13.040	12.411	+ 5.90
P. hysterophorus T and I	10.216	8.944	8.024	9.061	- 22.69
Polyalthia longifolia T	11.880	12.400	12.984	12.421	+ 5.98
P. longifolia T and I	9.992	9.144	8.312	9.149	- 21.94
Tauernaemontana divaricata T	11.864	12.400	13.008	21.424	+ 6.01
T . divaricata T and I	10.024	8.976	8.080	9.027	- 22.98
Curcuma longa T	11.904	12.408	13.000	12.437	+ 6.12
C. longa T and I	9.944	8.992	8.080	9.005	- 23.17
Acacia leucophloea T	12.008	12.424	13.088	12.507	+ 6.72
A. leucophloea T and I	9.992	9.008	7.912	8.971	- 23.46
Pongamia glabra T	12.008	12.424	13.016	12.483	+ 6.51
P. glabra T and I	9.888	9.000	8.040	8.976	- 23.41
Phyllanthus niruri T	12.016	12.384	13.120	12.507	+ 6.72
P. niruri T and I	9.968	8.992	7.920	8.960	- 23.55
Inoculated	9.720	8.944	7.584	8.749	- 25.35
Healthy	11.192	11.648	12.320	11.720	0.00
	Mean	11.063	10.808	10.567	
T-Treated I-Inoculated		CD (P = 0.05)			
* Mean of three replications				Treatment : 0.114; Days : 0.028; TxD : 0.197	

Reducing sugars

The reducing sugar content of rice plants *viz.* healthy, inoculated (diseased), plant products treated and plant products treated + inoculated plants showed the similar trend.

The inoculated plants exhibited the maximum (25.35%) reduction of reducing sugars, while plant products treated plants registered increase in reducing sugars varying from 2.39 to 6.72 per cent. The plant products treated plants following pathogen inoculation showed reduction in reducing sugar content varying from 14.04 to 23.55 per cent. The maximum (6.72%) increase of reducing sugars

Table 3. Effect of plant extracts on non-reducing sugars of rice plantsreducing sugars of Co 43 rice plants

Plant extracts	Non-reducing sugars (mg/g)* Days after inoculation				Non-reducing sugars increase (+) or decrease (-) (%)*
	7	14	21	Mean	
Neem oil - 3% T	8.123	9.816	9.656	9.198	+ 3.70
Neem oil –3% T and I	7.992	8.083	8.016	8.030	- 9.47
Neem seed kernel extract-5% T	8.192	9.803	9.669	9.221	+ 3.96
Neem seed kernel extract-5% T and I	8.003	8.061	8.032	8.032	- 9.45
Acalypha indica T	8.325	9.800	10.008	9.378	+ 5.73
A.indica T and I	7.883	7.707	8.061	7.884	- 11.12
Ocimum tenuiflorum T	8.421	9.765	9.955	9.380	+ 5.75
O. tenuiflorum T and I	7.888	7.704	7.651	7.748	- 12.65
Convolvulus arvensis T	8.317	10.003	9.829	9.383	+ 5.78
C. arvensis T and I	7.864	7.664	7.984	7.837	- 11.65
Catharanthus roseus T	8.480	9.816	10.051	9.449	+ 6.53
C. roseus T and I	7.981	7.661	7.752	7.798	- 12.09
Datura stramonium T	8.597	9.771	9.843	9.404	+ 6.02
D. stramonium T and I	7.013	7.520	7.560	7.364	- 16.98
Cymbopogon martini T	8.352	9.885	10.128	9.455	+ 6.60
C. martini T and I	7.147	7.499	7.379	7.342	- 17.23
Ipomoea carnea T	8.608	9.848	9.992	9.483	+ 6.91
I . carnea T and I	7.043	7.917	6.931	7.297	- 17.73
Pithecolobium dulce T	8.437	9.808	10.296	9.514	+ 7.26
P.dulce T and I	6.997	7.443	7.360	7.267	- 18.07
Bougainvillaea spectabilis T	8.453	9.749	10.275	9.492	+ 7.01
B. spectabilis T and I	7.056	7.523	7.328	7.302	- 17.68
Vitex negundo var. *purpu*		*rascense* T	8.413	9.757	10.189
9.453	+ 6.57				
V. negundo var. *purpurascense* T and I	7.293	7.400	7.280	7.324	- 17.43
Quisqualis indica T	8.629	9.856	10.099	9.528	+ 7.42
Q. indica T and I	7.813	7.552	6.339	7.235	- 18.43
Eucalyptus globulus T	8.499	9.728	10.312	9.513	+ 7.25
E. globules T and I	6.731	7.749	7.216	7.232	- 18.47
Phyllanthus emblica T	8.512	9.680	10.411	9.534	+ 7.49
P. emblica T and I	7.000	7.456	7.269	7.242	- 18.35
Thevetia peruviana T	8.339	9.848	10.264	9.484	+ 6.92
T. peruviana T and I	7.517	7.389	6.944	7.283	- 17.89
Euphorbia hirta T	8.531	9.773	10.400	9.568	+ 7.87
E.hirta T and I	7.120	7.336	7.216	7.224	- 18.56
Parthenium hysterophorus T	8.672	9.760	10.160	9.531	+ 7.45
P. hysterophorus T and I	6.819	7.621	6.973	7.138	- 19.53
Polyalthia longifolia T	8.536	9.733	10.269	9.513	+ 7.25
P. longifolia T and I	7.533	7.731	6.376	7.213	- 18.68
Tauernaemontana divaricata T	8.819	9.883	9.925	9.542	+ 7.58
T . divaricata T and I	6.947	7.408	6.875	7.077	- 20.21
Curcuma longa T	8.416	9.736	10.467	9.540	+ 7.55
C. longa T and I	7.037	7.040	6.939	7.005	- 21.03
Acacia leucophloea T	8.845	9.699	10.112	9.552	+ 7.69
A. leucophloea T and I	6.989	6.853	7.085	6.976	- 21.35
Pongamia glabra T	9.027	9.901	9.747	9.558	+ 7.76
P. glabra T and I	6.901	6.851	7.053	6.935	- 21.82
Phyllanthus niruri T	8.987	9.717	9.931	9.545	+ 7.61
P. niruri T and I	6.821	6.891	7.024	6.912	- 22.07
Inoculated	6.493	6.480	6.037	6.337	- 28.56
Healthy	7.827	9.280	9.504	8.870	0.00
	Mean	7.885	8.619	8.643	
T-Treated I-Inoculated		CD (P = 0.05)			
* Mean of three replications			Treatment : 0.141; Days : 0.035; TxD : 0.245		

was recorded in plants treated with *A. leucophloea* and *P. niruri* and the minimum(2.39%) increase was in the case of neem oil(3%). The maximum (23.55%) reduction of reducing sugars was observed in plants treated with the leaf extract (10%) of *P. niruri* following inoculation. The reducing sugar content was the highest (13.120mg/g) in the plants treated with the leaf extract (10%) of *P. niruri* 21 days after treatment (Table 2).

The contents of all sugar fractions (total soluble, reducing and non-reducing sugars) decreased after infection by *S. oryzae*. But the extent of reduction in

Table 4. Effect of plant extracts on total phenols of Co43 rice plants

Plant extracts	Total phenols (mg/g)*				Increase in total phenols (%)*
	Days after inoculation				
	7	14	21	Mean	
Neem oil – 3% T	0.881	0.832	0.826	0.846	4.70
Neem oil – 3% T and I	1.102	1.003	0.937	1.014	25.50
Neem seed kernel extract-5% T	0.874	0.830	0.826	0.843	4.33
Neem seed kernel extract-5% T and I	1.083	1.007	0.937	1.009	24.88
Acalypha indica T	0.862	0.827	0.825	0.838	3.71
A.indica T and I	1.062	0.952	0.920	0.978	21.04
Ocimum tenuiflorum T	0.860	0.825	0.823	0.836	3.47
O. tenuiflorum T and I	1.039	0.953	0.918	0.970	20.05
Convolvulus arvensis T	0.861	0.826	0.823	0.837	3.59
C. arvensis T and I	1.050	0.962	0.931	0.981	21.41
Catharanthus roseus T	0.858	0.826	0.821	0.835	3.34
C. roseus T and I	1.020	0.971	0.935	0.975	20.67
Datura stramonium T	0.854	0.824	0.821	0.833	3.09
D. stramonium T and I	1.018	0.943	0.871	0.944	16.83
Cymbopogon martini T	0.850	0.826	0.820	0.832	2.97
C. martini T and I	1.012	0.932	0.882	0.942	16.58
Ipomoea carnea T	0.848	0.826	0.822	0.832	2.97
I . carnea T and I	1.019	0.902	0.887	0.936	15.84
Pithecolobium dulce T	0.848	0.826	0.819	0.813	2.85
P.dulce T and I	1.008	0.908	0.877	0.931	15.22
Bougainvillaea spectabilis T	0.849	0.824	0.820	0.831	2.85
B. spectabilis T and I	1.006	0.915	0.863	0.928	14.85
Vitex negundo var. *purpurascense* T	0.815	0.825	0.820	0.832	2.97
V. negundo var. *purpurascense* T and I	1.027	0.905	0.849	0.927	14.73
Quisqualis indica T	0.840	0.825	0.819	0.828	2.48
Q. indica T and I	1.003	0.910	0.856	0.923	14.23
Eucalyptus globulus T	0.841	0.825	0.820	0.829	2.60
E. globulus T and I	1.004	0.904	0.863	0.924	14.36
Phyllanthus emblica T	0.836	0.824	0.821	0.827	2.35
P. emblica T and I	0.986	0.903	0.844	0.911	12.75
Thevetia peruviana T	0.840	0.823	0.818	0.827	2.35
T. peruviana T and I	1.002	0.905	0.847	0.918	13.61
Euphorbia hirta T	0.831	0.822	0.819	0.824	1.98
E.hirta T and I	0.989	0.898	0.846	0.911	12.75
Parthenium hysterophorus T	0.840	0.823	0.821	0.828	2.48
P. hysterophorus T and I	0.993	0.903	0.864	0.920	13.86
Polyalthia longifolia T	0.839	0.824	0.821	0.828	2.48
P. longifolia T and I	0.996	0.904	0.863	0.921	13.99
Tauernaemontana divaricata T	0.832	0.820	0.817	0.823	1.86
T. divaricata T and I	0.979	0.903	0.836	0.906	12.13
Curcuma longa T	0.834	0.819	0.818	0.824	1.98
C. longa T and I	0.978	0.898	0.851	0.909	12.50
Acacia leucophloea T	0.836	0.821	0.818	0.825	2.10
A. leucophloea T and I	0.971	0.893	0.845	0.903	11.76
Pongamia glabra T	0.831	0.822	0.819	0.824	1.98
P. glabra T and I	0.971	0.883	0.843	0.899	11.26
Phyllanthus niruri T	0.835	0.820	0.817	0.824	1.98
P. niruri T and I	0.985	0.905	0.858	0.916	13.37
Inoculated	0.980	0.890	0.740	0.870	7.67
Healthy	0.800	0.810	0.815	0.808	0.00
	Mean	0.928	0.874	0.846	
T-Treated I-Inoculated		CD (P = 0.05)		Treatment : 0.011;	Days : 0.003; TxD : 0.019
* Mean of three replications					

the plants sprayed with plant products followed by inoculation of the pathogen was significantly less. Similar changes were observed by Eswaran (1990) and Narassimmaraj (1991). Reduction in sugar content after the infection of *S. oryzae* was also reported (Alagarsamy *et al*., 1988). The reduction of sugars in the inoculated plants may be due to utilization of the sugars by fungus for their development or decreased synthetic activity of the infected tissue. It is also possible that the decrease in reducing sugars in the inoculated plants might be due to the utilization of reducing sugars for the synthesis of phenolic compounds via shikimic acid pathway (Uritani and Stahmann, 1961). In the

present study, the total soluble and reducing sugar contents significantly increased by the application of plant products, the maximum increase being in the plants sprayed with the leaf extact of *Acacia leucophloea* and *Phyllanthus niruri*. The minimum increase of total soluble and reducing sugars was recorded in the plants treated with neem oil. The maximum reduction of total soluble and reducing sugars was recorded in *P. niruri* sprayed along with pathogen inoculated plants. The minimum reduction of total soluble and reducing sugars was registered in neem oil sprayed and inoculated plants.

Non-reducing sugars

The maximum (7.87%) increase in non-reducing sugars was observed in plants treated with leaf extract (10%) of *E. hirta* followed by *P. glabra* (7.76%) while the minimum (3.70%) was in the case of neem oil (3%) followed by five per cent neem seed kernel extract (3.96%). The maximum (22.07%) reduction in non-reducing sugar content was observed in the plants treated with leaf extract (10%) of *P. niruri* following inoculation. The minimum per cent decrease in non-reducing sugars was 9.45 in the plants treated with neem seed kernel extract (5%) after inoculation followed by three per cent neem oil with inoculation (9.47%). It was the maximum (10.467mg/g) in the plants treated with leaf extract (10%) of *C. longa* 21 days after treatment which was on par with *P. emblica* (10.411), *E. hirta* (10.400), *Eucalyptus globulus* (10.312), *P. dulce* (10.296), *Bougainvillaea spectabilis* (10.275), *P. longifolia* (10.269) and *T. peruviana* (10.264). The lowest (6.037mg/g) non-reducing sugar content was recorded in the plants 21 days after inoculation without plant products treatment which was on par with *Q. indica* treated plants following inoculation (6.339mg/g) (Table 3).

The maximum increase in non-reducing sugar content was observed in plants sprayed with the leaf extracts of *Euphorbia hirta* and *Pongamia glabra,* while the minimum content with neem oil and neem seed kernel extract. The maximum reduction in non-reducing sugar content was registered in the plants sprayed with the leaf extracts of P*. niruri, P. glabra, A. leucophloea* and C*urcuma longa* following inoculation. The minimum decrease in non-reducing sugar content was observed in the plants treated with neem seed kernel extract. Similar observations were made by Narassimmaraj (1991) who found that the maximum increase in total sugars was in the plants sprayed with C*. arvensis* + barium hydroxide and *C. roseus* + dipotassium hydrogen phosphate. The plants sprayed with *C. roseus* + dipotassium hydrogen phosphate following inoculation with *S. oryzae* showed the minimum reduction in the total sugar content.

Total Phenols

Total phenol content of healthy plants showed a slight variation at different periods of sampling. A high total phenol content was observed in the plants 7 days after inoculation and it reduced with lapse of time. Application of plant products followed by inoculation tremendously increased the total phenols as compared to the plants treated with plant products without pathogen inoculation. The maximum total phenol content was observed in plants treated with plant products following inoculation 7 days after inoculation in all the cases. The phenol content increased to the maximum extent of 25.50 per cent in the plants treated with neem oil(3%) following inoculation.The minimum(1.86%) increase was recorded in the plants treated with leaf extract (10%) of *T. divaricata.* The highest (1.102mg/g) total phenol content was observed in the plants treated with neem oil (3%) seven days after inoculation and it was on par with neem seed kernel extract (5%) with inoculation (1.083mg/g). Plants 21 days after inoculation recorded the lowest (0.740mg/g) total phenol content (Table 4).

In the present investigation, the highest total phenol content was observed seven days after inoculation and it reduced with the lapse of time. Spraying of plant products followed by inoculation with the pathogen tremendously increased the total phenols as compared to without pathogen inoculation. The phenol content was increased to the maximum extent of 25.50 per cent in the plants sprayed with neem oil following inoculation followed by neem seed kernel extract, *C. arvensis*, and *A. indica* with inoculation. Velazhahan and Ramabadran (1993) reported that a significant increase in total phenols was detected in *S. oryzae*-inoculated rice plants of all age groups. Soon after infection, the plants probably mobilized all its defense mechanisms to the site of action resulting in increase in total phenols. The maximum amount of total phenols was present in the inoculated plants four days after inoculation followed by gradual reduction during advanced symptom development. The findings of Selvaraj (1990), corroborated with present ones who reported that rice plants sprayed with the seed extract of *Tribulus terrestris*, leaf extracts of *C. roseus* and *O. tenuiflorum* had greater amounts of phenols than *S. oryzae* inoculated and also healthy control plants. Similar findings were also documented by Narassimmaraj (1991), who observed that the total phenol content increased to the maximum in the plants sprayed with the leaf extracts of *C. roseus*, *A. indica* + barium hydroxide and *A. indica* + dipotassium hydrogen phosphate following *S. oryzae* inoculation.

Total protein

Total protein content of healthy rice plants progressively increased with increase in the age of the plants. Rice plants inoculated with the pathogen also had increased total protein (18.39%) with

Table 5. Effect of plant extracts on total protein of rice plants

Plant extracts	Total protein content (mg/g)*				Increase in total protein (%)*
	Days after inoculation				
	7	14	21	Mean	
Neem oil - 3% T	43.680	45.120	49.120	45.973	26.51
Neem oil –3% T and I	41.813	43.200	43.680	42.898	18.05
Neem seed kernel extract-5% T	43.840	45.280	49.600	46.240	27.25
Neem seed kernel extract-5% T and I	41.760	43.360	43.840	42.987	18.30
Acalypha indica T	43.093	45.920	49.067	46.027	26.66
A.indica T and I	41.867	43.147	43.840	42.951	18.20
Ocimum tenuiflorum T	42.880	44.533	48.160	45.191	24.36
O. tenuiflorum T and I	40.907	43.200	44.000	42.702	17.51
Convolvulus arvensis T	42.720	44.693	49.013	45.475	25.14
C. arvensis T and I	41.760	43.093	43.680	42.844	17.90
Catharanthus roseus T	42.933	44.533	49.120	45.529	25.29
C. roseus T and I	40.267	43.680	43.840	42.596	17.22
Datura stramonium T	41.440	43.200	45.333	43.324	19.23
D. stramonium T and I	39.360	42.560	42.667	41.529	14.29
Cymbopogon martini T	41.280	43.147	45.547	43.325	19.23
C. martini T and I	39.733	42.240	42.880	41.618	14.53
Ipomoea carnea T	40.320	42.240	45.120	42.560	17.12
I . carnea T and I	38.080	41.440	42.560	40.693	11.98
Pithecolobium dulce T	40.160	42.400	46.400	42.987	18.30
P.dulce T and I	38.880	41.600	41.920	40.800	12.28
Bougainvillaea spectabilis T	40.160	42.027	45.760	42.649	17.37
B. spectabilis T and I	39.040	41.760	42.080	40.960	12.72
Vitex negundo var. *purpurascense* T	40.533	42.027	45.600	42.720	17.56
V. negundo var. *purpurascense* T and I	39.200	41.707	42.240	41.049	12.96
Quisqualis indica T	39.893	41.333	44.693	41.973	15.51
Q. indica T and I	38.560	40.960	42.080	40.533	11.54
Eucalyptus globulus T	42.347	43.200	45.600	43.716	20.30
E. globulus T and I	39.627	43.147	43.307	42.027	15.66
Phyllanthus emblica T	39.360	41.547	43.360	41.422	13.99
P. emblica T and I	38.080	39.680	40.747	39.502	8.71
Thevetia peruviana T	40.000	42.400	44.480	42.293	16.39
T. peruviana T and I	37.760	41.440	42.400	40.533	11.54
Euphorbia hirta T	38.240	40.480	44.053	40.924	12.62
E.hirta T and I	38.400	40.000	40.160	39.520	8.757
Parthenium hysterophorus T	38.880	40.640	44.960	41.493	14.19
P. hysterophorus T and I	38.400	40.480	41.440	40.107	10.37
Polyalthia longifolia T	39.200	41.440	42.880	41.173	13.31
P. longifolia T and I	37.600	40.000	40.053	39.218	7.93
Tauernaemontana divaricata T	38.773	41.120	43.040	40.978	12.77
T . divaricata T and I	37.760	40.160	40.480	39.467	8.61
Curcuma longa T	38.240	41.440	42.613	40.764	12.18
C. longa T and I	37.333	39.520	40.480	39.111	7.63
Acacia leucophloea T	38.133	40.640	42.933	40.569	11.64
A. leucophloea T and I	37.120	39.093	40.213	38.809	6.80
Pongamia glabra T	38.347	41.013	42.933	40.764	12.18
P. glabra T and I	37.547	39.840	40.267	39.218	7.93
Phyllanthus niruri T	37.813	40.640	42.613	40.355	11.05
P. niruri T and I	37.280	39.040	40.213	38.844	6.90
Inoculated	39.787	42.507	46.773	43.022	18.39
Healthy	35.787	36.267	36.960	36.338	0.00
	Mean	39.719	41.883	43.696	
T-Treated I-Inoculated			CD (P = 0.05)		
* Mean of three replications				Treatment : 0.436;	Days : 0.107; TxD : 0.756

increase in age of the plants. Spraying of plant products remarkably increased the total protein and the maximum increase being 27.25 per cent in the plants treated with neem seed kernel extract (5%) followed by leaf extract (10%) of *A. indica* (26.66%). Inoculation of the pathogen in the plant products treated plants reduced the total protein content as compared to plant products treated uninoculated plants.The minimum increase (6.80%) was observed in the plants treated with the leaf extract (10%) of *A. leucophloea* following inoculation. The highest (49.600mg/g) total protein content was observed in the plants treated with neem seed kernel extract (5%) 21 days after treatment (Table

5). The present study revealed that the total protein content of the inoculated rice plants increased more rapidly with increase in the age of plants. Spraying of botanicals remarkably increased the protein content to the maximum of 27.25 per cent in the plants treated with neem seed kernel extract followed by the leaf extracts of *A. indica* and neem oil. The plants sprayed with botanicals and inoculated with *S. oryzae* had only less protein content. The increase in protein contents might be due to the presence of fungal protein in the inoculated plants and due to the presence of PR-proteins in botanicals sprayed plants. Selvaraj (1990) reported that a significant increase in protein content was observed in *S. oryzae*-inoculated rice plants than in plant products treated and healthy plants. Narassimmaraj (1991) found that spraying of plant extracts and chemicals increased the protein content and the maximum increase was registered in rice plants treated with the extract of *C. arvensis* + dipotassium hydrogen phosphate but without *S. oryzae* inoculation.

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