treatments. The correlations between days to 50 per cent tasseling and plant weight, days to 50 per cent cobing and cob weight, tassel length and plant weight were significant in control population, which were changed to non-significant in 12-day and 18-day accelerated ageing treatments respectively.

It is concluded that the induced variation observed in association with different phenotypic characters and the alteration of degree and nature of correlation due to ageing treatments helps to improve crop varieties through selection in appropriate direction in its major components, provided, it is genetic in nature. The genetic nature can be confirmed only in later generations.

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Biochemical factors for multiple resistance to foliar diseases of sorghum

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Abstract : Overall the multiple resistant genotypes recorded higher amount of sugars, phenols, O-dihydroxy phenols, proteins and amino acids as compared to genotypes susceptible to sooty stripe, zonate leaf spot, anthracnose and rust diseases. The amount of total sugars decreased significantly with the age of the plants whereas, amount of phenols and O-dihydroxy phenols increased significantly. However, uniform trend was not observed for soluble proteins and amino acid content did not vary with stage of the crop growth. The study revealed that higher sugars, phenols, O-dihydroxy phenols, soluble proteins and amino acids are some of the possible reasons for multiple resistance to foliar diseases in sorghum. *(Key Words: Sorghum, Biochemical, Disease, Resistance)*

It is well known that the disease resistance mechanism is a complex phenomenon and in response to invasion by a disease causing organism, plant produces various kinds of reactions. In recent years, it is becoming increasingly evident that several natural and induced defence mechanisms operate in host plants against different diseases. One such defence mechanism is the presence of certain biochemical compounds inhibitory to the pathogen (Prabhu *et al.*, 1984; Sing and Chand, 1982). During these processes considerable changes take place in biochemical and physiological aspects like changes in the concentrations of phenols (Prabhu *et al.*, 1984), orthodihydroxy phenols, carbohydrates, amino acids, proteins (Sharma and Sharma, 1994) in plant tissues and at the same time activities of various enzymes are also modified. Therefore, analysis of biochemicals in selected resistant and susceptible genotypes to sooty stripe, zonate leaf spot, anthracnose and rust diseases was carried out at three different stages to understand their role in resistance/susceptibility of sorghum genotypes.

Materials and Methods

Eight sorghum genotypes were selected for the study. Among the eight entries, four entries *viz.*, IS 3443, IS 14332, IS 8283 amd SPV 462 possessed multiple resistance to foliar diseases (*viz.*, sooty stripe, zonate leaf spot, anthracnose and rust) and four entries (CK 60 B, DMS 652, D 340 and 296 B) were susceptible to diseases. These entries were sown in two rows of 5 m length with three replications under RBD at Main Research Station, University of Agricultural Sciences, Dharwad during Kharif 1995-96. For different biochemical analysis, 3rd, 4th and 5th leaves from the top were collected at 50, 65 and 80 days after sowing (DAS) from random plants and composite leaf sample was made for estimation of sugars, phenols, proteins and amino acids in the ethanol extracts of fresh leaves of resistant and susceptible genotypes. Sugars were estimated by Nelson's modification of Somogy's method (Nelson, 1994). Phenols were estimated by Folin Ciocalteau Reagent (Bray and Thorpe, 1954). The orthodihydroxy phenols react with Arnow's reagent by producing a pink coloured complex and the intensity of which was measured at 510 nm (Arnow, 1937). Estimation of protein content in leaves was done as per the method given by Lowry *et al.*, (1951). Amino acids were estimated following ninhydrin method (Moore and Stein, 1958).

Results and Discussion

Total Sugars

In general, 51.6 per cent more of total sugar was recorded in resistant genotypes than the susceptible ones. Difference in sugar level at 50 DAS between resistant and susceptible genotypes was the least (300 mg). This may be due to inherent character of the genotypes as there was less disease development in all the genotypes especially in susceptible genotypes. Subsequently, the gap widened with respect to sugar content between resistant and susceptible genotypes (1323 mg/g to 456 mg/g). This indicated the utilization of these sugars by the invaded pathogens for their nutrition. Such nutritional utilization of sugars by the invading pathogens has been reported earlier (Krog *et al.*, 1961).

Total phenols

Resistant genotypes recorded high amount (4.62 mg/g) of phenols than susceptible ones (2.97 mg/g). The high phenolic content in resistant genotypes may be due to more sugar as it acts as precursor for synthesis of phenolics. The phenolic content in different genotypes significantly increased with increase in age of the plant. However, the rate of increase was significantly more in resistant genotypes (48 per cent) compared to susceptible ones (25 per cent (Table 2). These are in agreement with the findings of Naik *et al.*, (1984) and Prabhu *et al.*, (1984). In contrast, there are claims that susceptible cultivars contain high phenolic content (Aulakh *et al.*, 1971). Still another group of workers

Table 1. Total sugar content in resistant and susceptible sorghum genotypes

S.No.	Genotypes	Total sugars (µg/g fresh leaf weight)			
		50 DAS	65 DAS	80 DAS	Mean
	Resistant				
1.	IS 3443	1832.60	1178.72	1145.03	1385.45
2.	IS 14332	1473.78	988.40	891.93	1118.04
3.	IS 8283	1698.46	1066.11	1029.74	1264.77
4.	SPV 462	1636.36	1024.91	900.73	1187.33
	Mean	1660.30	1064.54	991.86	1238.90
	Susceptible				
5.	CK 60B	1385.78	892.78	509.30	929.29
6.	DMS 652	1378.11	636.35	473.57	829.35
7.	D 340	1303.34	584.23	427.63	771.73
8.	296 B	1227.72	572.77	414.80	738.43
	Mean	1323.74	671.53	456.33	816.20

Source	SEm±	C.D. (0.05)
Genotype	5074	144.42
Days	31.07	88.44
Genotypes x Days	87.89	250.15

Table 2. Total phenol content in resistant and susceptible sorghum genotypes

S.No.	Genotypes	Total phenols (mg/g fresh leaf weight)			
		50 DAS	65 DAS	80 DAS	Mean
	Resistant				
1.	IS 3443	3.61	3.80	5.46	4.29
2.	IS 14332	3.48	4.07	5.21	4.25
3.	IS 8283	4.51	5.46	5.84	5.27
4.	SPV 462	3.60	4.33	6.06	4.66
	Mean	3.80	4.42	5.64	4.62
	Susceptible				
5.	CK 60B	2.13	2.44	2.85	2.47
6.	DMS 652	2.91	2.91	3.41	3.08
7.	D 340	3.28	3.41	3.85	3.52
8.	296 B	2.14	2.84	3.43	2.80
	Mean	2.62	2.90	2.29	2.97

Source	SEm±	C.D. (0.05)
Genotype	0.23	0.66
Days	0.14	0.41
Genotypes x Days	0.40	N.S.

claim that there is no relation between resistance and phenolic contents of plants (Sokhi and Joshi, 1973). The variation in phenol content in different crop plants may be attributed to the unique characters of the phenolic compounds. Phenol molcule is constructed with lipophilic and hydrophilic portions.

Dihydroxy phenols

Dihydroxy phenols were more in multiple resistant genotypes as compared to susceptible ones. Further as the age of the crop increases, the O-dihydroxy phenols content also increased significantly (Table 3). However, irrespective of stage of the crop, multiple resistant genotypes recorded 53.81 per cent more O-dihydroxy phenols as compared to susceptible genotypes. Singh and Chand (1982) who opined that sorghum lines infected with *Helminthosporium rostratum* recorded higher concentration of total phenols and O-dihydroxy phenols in resistant lines than that of moderately resistant and highly susceptible lines.

Table 3. Dihydroxy phenol content in resistant and susceptible sorghum genotypes

S.No.	Genotypes	Orthodihydroxy phenols(mg/g fresh leaf weight)			
		50 DAS	65 DAS	80 DAS	Mean
	Resistant				
1.	IS 3443	2.35	2.48	3.47	2.76
2.	IS 14332	2.34	2.99	3.45	2.93
3.	IS 8283	2.81	3.47	3.96	3.41
4.	SPV 462	2.74	3.28	4.33	3.45
	Mean	2.56	3.06	3.80	3.14
	Susceptible				
5.	CK 60B	1.93	1.95	2.47	2.12
6.	DMS 652	2.20	2.41	2.87	2.49
7.	D 340	2.16	2.41	2.47	2.35
8.	296 B	1.74	1.78	2.34	1.95
	Mean	2.01	2.14	2.54	2.23
	Average Mean	2.28	2.60	3.17	2.69

Source	SEm±	C.D. (0.05)
Genotype	0.18	0.52
Days	0.11	0.32
Genotypes x Days	0.31	N.S.

It could be concluded that rapid accumulation of phenolic compounds occured in incompatible (resistant) genotypes than in the compatible (susceptible) ones.

Proteins

Protein content was almost same at 50 and 80 DAS whereas, it decreased at 65 DAS. Uritani (1971) reported that total protein increased at an early stage but decreased at the later stage due to degradative activity, which was more pronounced in diseases caused by facultative parasites. Resistant genotypes recorded 18-70 per cent more of soluble protein than the susceptible ones (Table 4). These are in agreement with the findings of Sharma and Sharma (1994) who reported increased concentration of protein in the resistant variety of maize to *Helminthosporium maydis*.

Amino acids

Resistant genotypes recorded significantly higher amount (66.63 per cent) of total amino acid as compared to susceptible ones. It has been reported that higher amino nitrogen content in the

Table 4. Soluble protein content in resistant and susceptible sorghum genotypes

S. No.	Genotypes	Soluble protein (mg/g fresh leaf weight)			
		50 DAS	65 DAS	80 DAS	Mean
	Resistant				
1.	IS 3443	5.94	4.62	6.28	5.61
2.	IS 14332	6.18	4.78	6.60	5.86
3.	IS 8283	7.70	5.45	7.10	6.75
4.	SPV 462	5.73	5.75	6.18	5.89
	Mean	6.39	5.15	6.54	6.03
	Susceptible				
5.	CK 60B	5.81	4.62	5.01	4.84
6.	DMS 652	5.15	4.36	5.01	4.84
7.	D 340	6.90	5.11	4.80	5.61
8.	296 B	4.48	4.31	4.65	4.48
	Mean	5.59	4.60	4.87	4.94

Source	SEm±	C.D. (0.05)
Genotype	0.22	0.63
Days	0.13	0.38
Genotypes x Days	0.38	1.08

Table 5. Total amino acid content in resistant and susceptible sorghum genotypes

S. No.	Genotypes	Total amino acid (μmole fresh leaves)			
		50 DAS	65 DAS	80 DAS	Mean
	Resistant				
1.	IS 3443	15.34	16.01	18.50	16.61
2.	IS 14332	15.16	16.81	17.47	16.48
3.	IS 8283	15.94	16.62	17.14	16.57
4.	SPV 462	15.38	16.78	18.92	17.03
	Mean	15.46	16.56	18.10	16.68
	Susceptible				
5.	CK 60B	11.43	9.77	8.76	9.99
6.	DMS 652	11.84	10.71	8.13	10.22
7.	D 340	11.34	1043	8.60	10.12
8.	296 B	11.11	9.69	8.28	9.69
	Mean	11.43	10.15	8.44	10.01

Source	SEm±	C.D. (0.05)
Genotype	0.68	1.93
Days	0.42	N.S.
Genotypes x Days	1.18	3.35

resistant host plants helped in the breakdown of naturally occuring phenols to toxic products which in turn inhibited the pathogens. The lower level of amino acids in early stage of the crop growth in susceptible genotypes (Table 5) indicated their inherent character. In later stage of the crop growth, there was wider gap which may be due to utilization by the fungus in susceptible genotypes as reported by Raghunathan *et al.*, (1966).

The study revealed that higher sugars, phenols, O-dihydroxy phenols, soluble proteins and amino acids are some of the possible reasons for multiple resistance to foliar diseases in sorghum.

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