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REGULAR ARTICLE

Role of phenolic compounds in resistance to chilli wilt

Nayeeema Jabeen¹, Nazir Ahmed¹, Muzafar Y. Ghani², Parvez A. Sofi^{3*}

¹ Division of Olericulture Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir Shalimar, Sriangar-191121, Jammu & Kashmir, India.

² Division of Post Harvest Technology, SKUAST-K, Sriangar-191121, Jammu & Kashmir, India.

³ Directorate of Research, Sriangar-191121, Jammu & Kashmir, India.

* Corresponding author: Parvez A. Sofi, E-mail: phdpbg@yahoo.com

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ABSTRACT

Fusarium wilt is a principle disease of chilli crop in Kashmir and has assumed a serious proportion. The varieties identified as resistant to a particular pathogen may not have desirable traits, however, can be used as donors. Two resistant and 6 susceptible chilli (*Capsicum annum* L.) genotypes and their twelve F_1 hybrids showing variable degree of resistance to *Fusarium* wilt were analyzed for phenols and phenolic enzymes, under both uninoculated and inoculated conditions at different growth stages. Generally total phenols ortho-dihydroxy phenols and the enzyme activity were invariably high in resistant parents and hybrids irrespective of growth stages, while, in case of susceptible parents the phenols content and enzyme activities were comparatively less. There existed a positive correlation between the host resistance and the amount of phenols and increased enzyme activities while it was almost the opposite in susceptible lines. The positive association of higher phenols and enzymes with resistance could be of immense value for early and quick identification of resistant genotypes during screening of large populations.

Key Words: chilli wilt; Fusarium pallidoroseum; phenolic compounds; resistance.

INTRODUCTION

Chilli (*Capsicum annuum* L.) is one of the most important vegetable and spice crop in India. It is commercially important because of its pungency and colour. Plants being sessile organism are exploited as a source of food and shelter by wide range of parasites including bacteria, fungi and viruses (Gachomo et al., 2003). Chilli is no exception and a fungal pathogen that invades chilli is *Fusarium spp.* and causes *Fusarium* wilt. The disease is known to be caused by *Fusarium pallidoroseum* (Cooke) Sacc. Recently it has become a serious problem in Kashmir (India) and presents a formidable challenge to chilli producers. The

ability of a plant to ward off a pathogenic attack depends upon the coordination of different defense strategies. Phenolic compounds have long been correlated with the resistance of plants to infective agents (Link et al., 1929; Link and Walker, 1933). There has been little work in India on *Fusarium* wilt and its inheritance pattern. We screened various sources for resistance between 1994 and 2002 and also carried out the inheritance studies revealing that resistance was monogenically inherited. This study was undertaken to study the status and nature of changes in various biochemical factors such as phenols, orthodihydroxy phenols, polyphenol oxidase and peroxidase with the objective of helping in the early screening and selection of desirable genotypes in wilt resistance breeding programmes.

MATERIALS AND METHODS

Studies on biochemical factors were conducted on uninoculated and inoculated resistant and susceptible cultivars and their crosses. The parents and crosses studied are:

Resistant parents (Arka Lohit , SH-C-1154); Susceptible parents (Kashmir Long-I, SH-C-101, SH-PC-1, SH-C-101, SH-PC-1 SH-C-405, Pampori and their twelve hybrids.

Resistant and susceptible parents were grown in the experimental area 2004 rainy season and crosses were made to develop F_1 's. Seed of parents and F_1 's was sown in the nursery in the 2005 rainy season for evaluation in pots to assess biochemical traits. Pots were 22.5 cm diameter and filled with sterilized autoclaved soil.

POT EVALUATION

Two sets of pots were used. Each set consisting of resistant and susceptible parents and their crosses. One set was kept as uninoculated control, where no fungal inoculum was added to the sterilized soil. The other set received fungal inoculum that was thoroughly mixed with the sterilized soil within the top layer at the rate of one inoculum flask pot⁻¹ and harboured *F. pallidoroseum* (38.92 x 103 cfu g⁻¹). Inoculated pots were placed under controlled conditions for 7 days. Nursery raised seedlings were then transplanted into pots after thoroughly washing their roots. There were 6 seedlings pot⁻¹ and the design was a randomized complete block design with three replicates. Six seedlings of each genotype were used to evaluate both enzyme and phenol studies in stage 1, i.e. stage just before inoculation.

SAMPLING TECHNIQUES

Samples were collected at four stages i.e. stages after transplanting (S1, S2, S3 and S4) for enzyme activity and at three different stages (S₁, S₂ and S₃) for phenols, from both the sets separately. Where S₁: was just before transplanting, S₂: was five days after transplanting, S₃: was 10 days after transplanting and S₄: was 30 days after transplanting. For enzyme activity (peroxidase and polyphenol oxidase), fresh samples were used that were collected between 9 am. and 10 am. At all the stages 4th, 5th and 6th leaves from top of each plant were picked from both inoculated and uninoculated plants of parents and hybrids. The collected leaves were washed and bulked and 2 g of the fresh bulked sample was used for enzyme analysis. The remaining bulked leaves were dried, powdered and used for phenol estimation. Peroxidase and Polyphenol oxidase enzymes were estimated by the method of Mahadevan and Sridhar (1986). Total phenols were determined by the method of Bray and Thorpe (1954).

Statistical analysis was carried out in R (R Development Core Team, 2009) for analysis of variance which is implementation of Box et al. (1978) design.

RESULTS AND DISCUSSION

Initially the total phenols ranged from 3.40 mg/g in (SH-C-405) to 6.50 mg/g (Kashmir Long-1) in the susceptible genotypes (Table 1). It ranged from 6.90 mg/g (SH-C-1154) to 7.60 mg/g (Arka Lohit) in the resistant parents. In the hybrids it ranged from 7.20 mg/g in Arka Lohit x SH-C-405 to 9.80 mg/g in Arka Lohit × Kashmir Long-1).

By the 2nd stage the total phenolic levels fell with inoculation in susceptible and resistant parents and the hybrids compared with uninoculated healthy, susceptible and resistant parents and hybrids.

At the 3rd phenological stage i.e. 30 days after inoculation there was a significant increase in the total phenols in uninoculated susceptible and resistant parents and hybrids. Without inoculation, total phenolic content decreased both in the resistant and susceptible parents and the hybrids. Variation in the total phenol content increased with the plant age irrespective of resistance level and inoculation treatment. In parental lines, the phenol content increased significantly irrespective of genotypes but the resistant parent and hybrids generally had a higher phenol content than susceptible lines. In the hybrids after initial increase in S₂, it decreased significantly from then on in uninoculated plants. However, with inoculation there was a significant decrease in total phenol content of the genotypes but it was significantly lower in susceptible parents than in resistant parents. In the hybrids total phenol content decrease and peroxidases. Similar observations were also made in three chilli varieties against fruit rot disease (Borua and Das, 2000) and in seedlings of pigeon pea resistant to wilt particularly during the early stages of growth (Bray and Thorpe, 1954).

Initial ortho-dihydroxy phenolic levels ranged from 0.17 to 0.19 mg g-1 in resistant parents while in susceptible parents, the ortho-dihydroxy phenolic levels was minimum (0.02 mg g^{-1}) than the resistant parents (Table 2). In hybrids a minimum value of 0.21 mg g⁻¹ was recorded in SH-C-1154 × Kashmir Long-1 and maximum of 0.55 mg g⁻¹ in Arka Lohit × SH-C-405. In the 1st phonological stage, the mean value of ortho-dihydroxy phenols was 0.18 mg/g in resistant parents, 0.03 mg g^{-1} in susceptible parents and 0.32 mg g^{-1} in hybrids. There was a higher level of ortho-dihydroxy phenols in the hybrids followed by resistant parents and susceptible parents. In phenological stage 2, the ortho-dihydroxy phenols significantly increased both under uninoculated and inoculated conditions as compared to S1 and S3. 30 days after inoculation. With advancing age and growth of plants, all the resistant parents and the hybrids had significantly increased ortho-dihydroxy phenols both under uninoculated and inoculated conditions,. However, the level of ortho-dihydroxy phenol was much higher in resistant parents and hybrids than susceptible genotypes. Generally, in total phenols, the level of ortho-dihydroxy phenols was high in resistant parents and hybrids in all the growth stages. They maintained their high level even after inoculation compared with susceptible genotypes whose ortho-dihydroxy phenols fell drastically after inoculation. It seems, that in resistant genotypes, the ortho-dihydroxy. phenols are continuously produced and maintain their level to provide protection from invading and infected wilt pathogen. There was a significant increase of ortho-dihydroxy phenols with the increased leaf age of groundnut affected by tikka leaf spot disease caused by Cercospora arachidicola (Sindhan and Jaglan, 1987) and in cowpea cultivar Co-A resistant to Xanthomonas vigincola, Burk. compared to a susceptible cultivar C-M-11 (Mohan et al., 1978). These findings conform to the findings of this study. The higher levels of ortho-dihydroxy phenols in resistant cultivars/hybrids after inoculation was expected because orthodihydroxy phenol compounds are possibly released and oxidized by polyphenol oxidase and peroxidase to the corresponding quinones before they become effective in combating the pathogen.

Polyphenol oxidase (PPO) values ranged from 0.12 to 0.16 units minute⁻¹ in the resistant parent, 0.02 to 0.08 units minute⁻¹ in the susceptible parents at S₁. In the hybrids it ranged from 0.47 to 0.99 units minute⁻¹ (Table 3). At the S₂ the uninoculated genotypes had minimum polyphenol oxidase activity of 0.80 units minute⁻¹ in the susceptible parents while in the resistant parents it was 3.04 units minute⁻¹ and in the hybrids significantly higher PPO activity (3.56 units minute⁻¹) .The PPO activity varied significantly among genotypes under both inoculated and uninoculated conditions in all the three plant phenological stages. Polyphenol oxidase activity of different inoculated and uninoculated genotypes increased with the advanced plant stage. In inoculated genotypes PPO activity showed an initial rapid increase but decreased by the final stage. However, in resistant parents and hybrids the PPO activity increased with the advanced plant growth stage.

The role of phenols becomes clear when the enzymes polyphenol oxidase and peroxidase are studied together. Polyphenol oxidase (PPO) and peroxidase activities (units minute-1) during the initial stages were more in the hybrids followed by resistant parents, but were lower in the susceptible parents (Tables 3 and 4). The activity increased at the S₂, S₃ and S_4 in all the uninoculated genotypes. The increase was greater in the resistant parents than in susceptible ones. Immediately after inoculation (S_2) and later the enzyme activity increased rapidly in resistant hybrids and resistant parents as compared with controlled uninoculated healthy plants and their activity increased until S₄. In the susceptible parents PPO activity decreased immediately and continued down. By S₄ the activity was down to zero except for peroxidase activity in S_2 and S_3 where it increased slightly immediately after inoculation. Similar results of higher enzyme activity were observed in sunflower cultivars resistant to charcoal rot (Rhizoctonia bataticola (Taub) Butler) as compared to susceptible varieties (Pathak et al., 1998), in pea cultivars resistant to powdery mildew (*Erisiphe polygonic* DC) than in susceptible cultivars (Guleria et al., 1998), in leaf rust of wheat (Sharma and Sharma, 1998), in buckeye rot of tomato (Singh et al., 1997) and for peroxidase in tomato cultivars resistant to Fusarium wilt than susceptible ones (Jagadeesh et al., 2002), higher (PPO) activity was observed in urd bean resistant variety PU-35 as compared to the susceptible T-9 variety (Malik et al., 2002). An increased level of polyphenol oxidase and peroxidase was found in the resistant than in susceptible material infected with chilli cucumber mosaic leading to the formation of more quinones and other oxidative products was also observed (Singh et al., 2003) Similarly with Yellow Vein Mosaic Virus in okra (Ahmed et al., 1992) and in Fusarium wilt in tomato increased peroxidase and PPO activity was found in resistant hosts following inoculation with Fusarium oxysporum (Retig, 1974).

Peroxidase activity ranged from 0.80 to 19.42 units minute⁻¹ under uninoculated and 0.00 to 19.53 units minute⁻¹ under inoculated conditions. The differences were significant among the genotypes as well as between inoculated and uninoculated conditions at all the three plant growth stages. Peroxidase activity increased with the plant growth stage. In inoculated susceptible genotypes the peroxidase activity increased rapidly in the initial stage but later decreased to 0.00 units minute⁻¹. However, in resistant parents and hybrids the peroxidase level increased with the plant growth stage.

Total phenols, ortho-dihydroxy phenols and enzyme activity were found generally, higher in the resistant parents and the hybrids irrespective of the growth stages. Their activity increased further after inoculation and continued untill S_4 . The higher amounts of total phenols and ortho-dihydroxy phenols in the resistant parents and hybrids were accompanied by increased activities of PPO and peroxidase, resulting in more oxidation of phenolic substances to form more toxic quinones and other oxidative products. These oxidative products might be the key to combating the pathogen in the resistant host. On the other hand, lower amount of phenols and lower enzyme activities in the susceptible parents, failed to produce toxic quinones or other oxidative products to that extent as found in resistant hybrids and parents. In the later stages the enzyme activity was almost nil in the susceptible ones providing no protection against Fusarium wilt leading to death of the plants.

The increased peroxidase and polyphenol oxidase activity and changes in the phenolic constituents immediately after infection are normal responses of a host plant (irrespective of its ultimate reaction to disease) in putting up initial defense as observed and reported by Harbourne (1964). This mechanism breaks down in susceptible genotypes as found here probably due to lower synthesis of phenolic enzymes and substrates. However, it persists in the resistant hosts.

S. No.	Genotypes	Un-inocu inoculate	ulated/ ed	Stage 1	Stage 2	Stage 3	Mean
	Resistant parents						
1.	Arka Lohit		UI	7.600	7.800	9.020	8.410
			Ι		7.580	6.510	7.045
2.	SH-C-1154		UI	6.900	7.450	9.420	8.435
			Ι		7.240	5.440	6.340
		Means	UI	7.250	7.630	9.220	
			Ι		7.410	5.980	
	Susceptible parents						
1.	Kashmir Long-1		UI	6.500	7.020	8.030	7.525
	C		Ι		6.210	6.400	6.305
2.	Pampori		UI	6.300	6.803	7.020	6.912
	-		Ι		6.000	5.230	5.615
3.	SH-C-1-01		UI	4.000	4.900	5.320	5.110
			Ι		3.810	3.710	3.760
4.	SH-PC-1		UI	4.800	5.220	5.910	5.565
			T		4.210	4.220	4.215
5.	SH-C-405		UI	3.400	3.730	4.040	3.885
			T		3.050	3.240	3.145
6	Local Chilli		- UI	6 000	6 490	7 050	6 770
0.			I	0.000	5 650	5 720	5 685
		Means	I II	5 170	5 690	6 230	0.000
		means	I	0.170	4 820	4 750	
	Hybrids		1		1.020	1	
1	Arka Lobit x Kashmir Long-1		IП	9 800	10.400	7 860	9 1 3 0
1.	Tiku Loint x Kusimin Long T		I	2.000	9 830	5 550	7 690
2	Arka Lohit x Local Chilli		I II	8 920	9.960	7 140	8.550
<u> </u>	Alina Bolite & Bocal Chilli		I	0.020	9,600	4 340	6.970
3	Arka Lobit x SH-C-101		III	7 850	8 797	6.830	7 813
0.			I	7.000	8 303	5.600	6.952
4	Arka Lohit x SH-PC-1		III	7 530	8.420	6 550	7 485
ч.			I	7.000	8.090	4 810	6.450
5	Arka Lohit x SH-C-405		I II	7 200	8 230	6 140	7 815
0.			I	7.200	7 810	4 030	5 920
6	Arka Lohit x Pampori		I II	9 250	10.560	7 800	9.180
0.	Tina Bonie X Fampon		I	9.200	9 800	3 420	6.610
7	SH-C-1154 x Kashmir Long-1		I II	7 540	8 690	6.620	7 655
			I	7.010	8 330	4 740	6.535
8	SH-C-1154 x Local Chilli		I II	8 530	9 820	6 240	8.030
0.			I	0.000	9 100	3 310	6 205
9	SH-C-1154 x SH-C-101		ц П	7 600	8 430	5 030	6 730
<i>.</i>			I	7.000	8.020	4 410	6 215
10	SH-C-1154 x SH-PC-1		I II	7 200	9.540	5 740	7 640
10.			I	7.200	8 930	4 800	6 865
11	SH-C-1154 x SH-C-405		I II	8 200	9.250	6.410	7 830
11.	511 € 1104 × 511 € 405		I	0.200	7 840	4 620	6 230
12	SH-C-1154 x Pampori		- UI	8.360	9 450	6 220	7 835
			I.	0.000	9 010	4.330	6 670
			- UI	8 170	9.300	6.550	0.070
		Means		0.170	0.500	4.500	
		meuno	1		8.720	4.500	

Table 1. Total phenol concentration (mg/g) in un-inoculated/inoculated chilli genotypes at different stages.

LSD= Genotypes (0.068^{***}), Stage (0.021^{***}), Inoculation (0.021^{***}), Genotype x Stage (0.096^{***}), Genotype x Inoculation (0.096^{***}), Stage x Inoculation (0.030^{***}), Genotype x Stage x Inoculation (0.136^{***})

Resistant parents I Arka Lohit UI 0.190 0.430 1.960 0. 2. SH-C-1154 I 0.450 1.946 0. 2. SH-C-1154 UI 0.170 0.390 1.420 1. I 0.400 1.400 0. Means UI 0.18 0.41 1.69 Susceptible parents I 0.400 0.130 1.060 0. 2. Pampori UI 0.040 0.230 1.240 0. 3. SH-C-101 UI 0.040 0.230 1.240 0. 4. SH-PC-1 UI 0.020 0.150 1.400 0. 5. SH-C-405 UI 0.020 0.150 1.400 0. 6. Local Chilli UI 0.020 0.150 1.600 0. 6. Local Chilli UI 0.03 0.16 1.23 0.700 1.740 1. 2.	S. No.	Genotype	Uninocu	lated/ Inoculated	Stage 1	Stage 2	Stage 3	Mean
1. Arka Lohit UI 0.190 0.430 1.960 0. 1 0.450 1.946 0. 2. SH-C-1154 UI 0.170 0.390 1.420 0. Means UI 0.18 0.41 1.69 0. Means UI 0.18 0.41 1.69 0. Susceptible parents I 0.400 0.30 1.60 0. 1. Kashmir Long-1 UI 0.040 0.30 1.60 0. 2. Pampori I 0.040 0.30 1.240 0. 3. SH-C-101 UI 0.040 0.30 0.150 1.400 0.0 4. SH-PC-1 UI 0.020 0.110 1.020 0. 5. SH-C-405 UI 0.030 0.200 1.620 0.0 6. Local Chilli UI 0.030 0.200 1.620 0.0 6. Local Chilli UI 0.220 0.700 1.2 0.000 0.0 0.0 0.		Resistant parents						
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	1.	Arka Lohit		UI	0.190	0.430	1.960	0.860
2. SH-C-1154 UI 0.170 0.390 1.420 1. I 0.400 1.400 0.700 1.400 0.700 Means UI 0.18 0.41 1.69 1. Susceptible parents I 0.430 1.60 0.00 2. Pampori UI 0.040 0.230 1.240 0. 3. SH-C-1-01 UI 0.030 0.150 1.400 0.00 3. SH-C-1-01 UI 0.020 0.110 1.020 0.0 4. SH-PC-1 UI 0.020 0.110 1.020 0.0 5. SH-C-405 UI 0.020 0.150 1.600 0.0 6. Local Chilli UI 0.030 0.200 0.700 0.700 6. Local Chilli UI 0.030 0.200 1.620 0.700 7. Arka Lohit x Kashmir Long-1 UI 0.200 0.740 1. 7. Arka Lohit x SH-C-101 UI 0.200 0.650 1.100 0.650				Ι		0.450	1.946	0.875
I 0.400 1.400 0.0 Means UI 0.18 0.41 1.69 Susceptible parents I 0.43 1.67 0.60 I 0.830 0.130 0.160 0.0 I 0.840 0.130 0.60 0.7 I 0.600 0.230 1.240 0.0 I 0.040 0.230 1.240 0.0 I 0.030 0.150 1.400 0.0 I 0.030 0.150 1.400 0.0 I 0.030 0.150 1.400 0.0 I 0.020 0.150 1.000 0.0 I 0.020 0.150 1.000 0.0 I 0.020 0.150 1.000 0.0 I 0.030 0.200 1.620 0.0 I 0.030 0.160 0.0 0.0 I 0.030 0.160 0.0 0.0	2.	SH-C-1154		UI	0.170	0.390	1.420	1.290
Means UI 0.18 0.41 1.69 I 0.43 1.67 Susceptible parents I 0.040 0.130 1.060 0. I 0.040 0.20 0.470 0. 2. Pampori UI 0.040 0.20 1.400 0. 3. SH-C-101 UI 0.030 0.150 1.400 0. 4. SH-PC-1 UI 0.020 0.110 1.020 0.0 5. SH-C-405 UI 0.020 0.150 1.600 0. 6. Local Chilli UI 0.030 0.200 1.620 0.0 6. Local Chilli UI 0.030 0.200 1.620 0.0 7 Means UI 0.030 0.200 1.620 0.0 7 Means UI 0.30 0.200 1.620 0.0 8 UI 0.300 0.160 1.23 1.23				Ι		0.400	1.400	0.900
I 0.43 1.67 Susceptible parents I 0.043 0.060 1 0.090 0.130 0.060 2. Pampori II 0.040 0.230 1.240 0. 3. SH-C-1-01 I 0.100 0.300 0.150 1.400 0. 4. SH-PC-1 II 0.020 0.110 1.020 0. 5. SH-C-405 II 0.020 0.150 1.060 0.0 5. SH-C-405 II 0.020 0.150 1.060 0.0 6. Local Chilli UI 0.030 0.200 1.620 0.0 6. Local Chilli II 0.030 0.200 1.620 0.0 7 Arka Lohit x Kashmir Long-1 II 0.030 0.201 1.23 1.23 7 Arka Lohit x SH-C-101 II 0.200 0.700 1.23 8 I_Virids I 0.700 1.700 1.23 7 Arka Lohit x SH-C-101 UI 0.200 0.700			Means	UI	0.18	0.41	1.69	
Susceptible parents VI 0.040 0.130 0.060 0. 1 1 0.090 0.470 0. 2. Pampori 11 0.040 0.230 1.240 0. 3. SH-C-1-01 II 0.030 0.150 1.400 0. 3. SH-PC-1 II 0.030 0.150 1.400 0. 4. SH-PC-1 II 0.020 0.150 1.060 0. 5. SH-PC-1 II 0.020 0.150 1.060 0. 6. Local Chilli II 0.030 0.16 1.23 1.000 6. Local Chilli II 0.030 0.16 1.23 1.000 6. Local Chilli II 0.030 0.16 1.23 1.000 1. Arka Lohit x Kashmir Long-1 II 0.33 0.16 1.23 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000				Ι		0.43	1.67	
1. Kashmir Long-1 UI 0.400 0.130 1.060 0. 2. Pampori I 0.090 0.470 0. 2. Pampori I 0.100 0.230 1.240 0. 3. SH-C-1-01 UI 0.030 0.150 1.400 0. 4. SH-PC-1 I 0.020 0.150 1.400 0. 5. SH-PC-1 I 0.020 0.150 1.060 0. 5. SH-C-405 UI 0.020 0.150 1.060 0. 6. Local Chilli UI 0.020 0.150 1.060 0. 6. Local Chilli UI 0.030 0.200 1.600 0. 6. Local Chilli UI 0.33 0.6 1.23 1. 7 Arka Lohit x Kashmir Long-1 UI 0.220 0.740 1.790 1. 1 Arka Lohit x SH-C-101 UI 0.220 0.670 1.650 1.00 3. Arka Lohit x SH-C-405 UI 0.5		Susceptible parents						
10.0900.4700.02.PamporiUI0.0400.2301.2400.3.SH-C-1-01UI0.0300.1501.4000.4.SH-PC-1UI0.0200.1101.0200.5.SH-C-405I0.0200.1501.0600.5.SH-C-405I0.0200.1501.0600.6.Local ChilliUI0.0300.2001.6200.6.Local ChilliUI0.0300.2001.6200.7MeansUI0.0300.2001.6200.8UI0.0300.2001.6200.0.9MeansUI0.2200.7401.7901.1Arka Lohit x Kashmir Long-1UI0.2200.7401.7001.2.Arka Lohit x Local ChilliI0.6501.1000.3.Arka Lohit x SH-C-101UI0.2700.9601.6201.4.Arka Lohit x SH-C-101UI0.5501.1001.9401.5.Arka Lohit x SH-C-405UI0.5501.1001.9401.5.Arka Lohit x SH-C-405UI0.5501.1001.9401.5.Arka Lohit x SH-C-405UI0.5501.1001.9401.6.Arka Lohit x SH-C-101UI0.2300.5901.0001.7.SH-C-1154 x Kashmir Long-1I0.690 <td>1.</td> <td>Kashmir Long-1</td> <td></td> <td>UI</td> <td>0.040</td> <td>0.130</td> <td>1.060</td> <td>0.595</td>	1.	Kashmir Long-1		UI	0.040	0.130	1.060	0.595
2. Pampori UI 0.040 0.230 1.240 0. I I 0.110 0.390 0. 3. SH-C-1-01 UI 0.030 0.150 1.400 0. 4. SH-PC-1 UI 0.020 0.110 1.020 0. 5. SH-C-405 UI 0.020 0.150 1.060 0. 6. Local Chilli UI 0.020 0.150 1.600 0. 6. Local Chilli UI 0.030 0.200 1.620 0. Means UI 0.030 0.200 0.710 0. Means UI 0.030 0.200 0.700 0. Hybrids I 0.030 0.670 1.050 0. 1 Arka Lohit x Kashmir Long-1 UI 0.220 0.740 1.790 1. 2. Arka Lohit x SH-C-101 UI 0.270 0.660 1.650 1.00 3. Arka Lohit x SH-C-101 UI 0.440 1.020 1.920 1.				Ι		0.090	0.470	0.280
I 0.110 0.390 0. 3. SH-C-1-01 UI 0.030 0.150 1.400 0. 4. SH-PC-1 UI 0.020 0.110 1.020 0. 5. SH-C-405 UI 0.020 0.150 1.660 0. 5. SH-C-405 UI 0.020 0.150 1.660 0. 6. Local Chilli UI 0.030 0.16 1.23 0. 6. Local Chilli UI 0.03 0.16 1.23 0. Means UI 0.03 0.16 1.23 0. 0. 1 0.200 0.700 0.700 1.740 1. 1 0.48 UI 0.230 0.670 1.050 0. 1 0.700 1.740 1. 0.700 1.740 1. 2. Arka Lohit x Kashmir Long-1 UI 0.270 0.670 1.050 0. 3. Arka Lohit x SH-C-101 UI 0.270 0.650 1.100 1.650 1. <td>2.</td> <td>Pampori</td> <td></td> <td>UI</td> <td>0.040</td> <td>0.230</td> <td>1.240</td> <td>0.735</td>	2.	Pampori		UI	0.040	0.230	1.240	0.735
3. SH-C-1-01 UI 0.030 0.150 1.400 0. 4. SH-PC-1 UI 0.020 0.110 1.020 0. 5. SH-C-405 UI 0.020 0.150 1.060 0.430 0. 5. SH-C-405 UI 0.020 0.150 1.600 0. 0. 6. Local Chilli UI 0.030 0.200 1.620 0. 0. 6. Local Chilli UI 0.300 0.160 1.23 0. 0				Ι		0.110	0.390	0.250
I0.0800.1900.4.SH-PC-1UI0.0200.1101.0200.65.SH-C-405UI0.0200.1501.0600.6.Local ChilliUI0.0300.2001.6200.6.Local ChilliUI0.0300.1601.0.70.9900.7100.1.0.300.161.238UI0.030.161.230.1.9100.300.161.230.161.239110.200.7401.791.1.971.00.200.7401.791.10.7001.7401.1.1.1.2.Arka Lohit x Kashmir Long-1UI0.2000.6701.6201.10.7001.7401.1.0.7001.7401.2.Arka Lohit x SH-C-101UI0.2700.9601.6201.3.Arka Lohit x SH-C-101UI0.2700.9601.6201.4.Arka Lohit x SH-PC-1UI0.3300.7501.4301.5.Arka Lohit x PamporiUI0.3300.7501.4301.6.Arka Lohit x PamporiUI0.2300.5901.6501.7.SH-C-1154 x Kashmir Long-1UI0.2300.5401.0200.9.SH-C-1154 x SH-C-101UI0.2300.540	3.	SH-C-1-01		UI	0.030	0.150	1.400	0.775
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$				Ι		0.080	0.190	0.135
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	4.	SH-PC-1		UI	0.020	0.110	1.020	0.565
5. SH-C-405 UI 0.020 0.150 1.060 0. 6. Local Chilli UI 0.030 0.200 1.620 0. 6. Local Chilli UI 0.030 0.200 1.620 0. Means UI 0.030 0.16 1.23 1 0.28 0.45 Hybrids I 0.200 0.740 1.790 1.1 1 0.700 1.740 1.1 2. Arka Lohit x Kashmir Long-1 UI 0.220 0.670 1.050 0.0 3. Arka Lohit x Local Chilli UI 0.250 0.670 1.500 0.1 3. Arka Lohit x SH-C-101 UI 0.270 0.960 1.620 1.1 4. Arka Lohit x SH-C-101 UI 0.440 1.020 1.920 1.1 5. Arka Lohit x SH-C-101 UI 0.330 0.750 1.430 1.1 6. Arka Lohit x Pampori UI 0.330 0.750 1.430 1.1 7. SH-C-1154 x Kashmir Long-1 I 0				Ι		0.060	0.430	0.245
6. Local Chilli I 0.050 0.500 0. 6. Local Chilli UI 0.030 0.200 1.620 0. I 0.090 0.710 0. 0. 0.080 0.710 0. Means UI 0.03 0.16 1.23 1. 0.280 0.280 0.28 0.28 0.28 0.28 0.28 0.28 0.28 0.28 0.28 0.28 0.28 0.28 0.28 0.28 0.28 0.28 0.20 1.4 0.20 1.4 0.20 1.740 1. 1. 0.700 1.740 1. 1. 1.50 0.670 1.050 0.670 1.050 0.670 1.050 0.670 1.050 0.670 1.050 0.670 1.620 1.100 0.30 1.650 1.100 1.510 1.51 1.51 1.650 1.100 1.650 1.100 1.650 1.510 1.51 1.51 1.51 1.51 1.51 1.51 1.51 1.51 1.51 1.51 1.51 1.51 1.51 1.51	5.	SH-C-405		UI	0.020	0.150	1.060	0.605
6. Local Chilli UI 0.030 0.200 1.620 0. I 0.090 0.710 0. Means UI 0.03 0.16 1.23 Hybrids 1 0.28 0.45 1 1. Arka Lohit x Kashmir Long-1 UI 0.200 0.740 1.790 1. 2. Arka Lohit x Local Chilli UI 0.250 0.670 1.050 0.0 3. Arka Lohit x SH-C-101 UI 0.270 0.960 1.620 1. 4. Arka Lohit x SH-C-101 UI 0.270 0.960 1.620 1. 4. Arka Lohit x SH-C-101 UI 0.440 1.020 1.920 1. 5. Arka Lohit x SH-C-405 UI 0.440 1.020 1.920 1. 6. Arka Lohit x SH-C-405 UI 0.330 0.750 1.430 1. 7. SH-C-1154 x Kashmir Long-1 UI 0.230 0.590 1.000 0. 8. SH-C-1154 x SH-C-101 UI 0.230 0.590 1.000 </td <td></td> <td></td> <td></td> <td>Ι</td> <td></td> <td>0.050</td> <td>0.500</td> <td>0.275</td>				Ι		0.050	0.500	0.275
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	6.	Local Chilli		UI	0.030	0.200	1.620	0.910
Means UI 0.03 0.16 1.23 Hybrids I 0.28 0.45 Hybrids I 0.20 0.740 1.790 $1.$ 1. Arka Lohit x Kashmir Long-1 UI 0.220 0.740 1.790 $1.$ 2. Arka Lohit x Local Chilli UI 0.250 0.670 1.050 0.650 3. Arka Lohit x SH-C-101 UI 0.270 0.960 1.620 1.100 3. Arka Lohit x SH-C-101 UI 0.440 1.020 1.920 1.1 4. Arka Lohit x SH-C-101 UI 0.440 1.020 1.920 1.1 5. Arka Lohit x SH-C-405 UI 0.550 1.100 1.940 1.6 6. Arka Lohit x Pampori UI 0.330 0.750 1.430 1.430 7. SH-C-1154 x Kashmir Long-1 UI 0.230 0.590 1.000 0.90 8. SH-C-1154				Ι		0.090	0.710	0.400
I0.280.45HybridsI0.200.7401.7901.IArka Lohit x Kashmir Long-1I0.2000.7401.7901.I0.7001.7401.1.0.7001.7401.2.Arka Lohit x Local ChilliUI0.2500.6701.0500.I0.6501.1000.1.0.6501.1000.3.Arka Lohit x SH-C-101UI0.2700.9601.6201.I0.9301.6501.1.0.9301.6501.4.Arka Lohit x SH-PC-1UI0.4401.0201.9201.5.Arka Lohit x SH-C-405UI0.5501.1001.9401.5.Arka Lohit x SH-C-405UI0.3300.7501.4301.6.Arka Lohit x PamporiUI0.3300.7501.4301.7.SH-C-1154 x Kashmir Long-1I0.2000.6901.7001.8.SH-C-1154 x SH-C-101UI0.2200.8701.6501.10.SH-C-1154 x SH-C-101I0.3900.9201.4901.11.SH-C-1154 x SH-C-105UI0.4500.9001.4701.11.SH-C-1154 x SH-C-405UI0.4500.9001.4701.			Means	UI	0.03	0.16	1.23	
Hybrids 1. Arka Lohit x Kashmir Long-1 UI 0.220 0.740 1.790 1. I I 0.700 1.740 1. 1. 0.700 1.740 1. 2. Arka Lohit x Local Chilli UI 0.250 0.670 1.050 0. I 0.650 1.100 0. 1. 0.650 1.000 0. 3. Arka Lohit x SH-C-101 UI 0.270 0.960 1.620 1. I 0.930 1.650 1.00 0. 1. 1.000 1.920 1. 4. Arka Lohit x SH-C-101 UI 0.440 1.020 1.920 1. 5. Arka Lohit x SH-C-405 UI 0.550 1.100 1.940 1. 5. Arka Lohit x Pampori UI 0.330 0.750 1.430 1. 6. Arka Lohit x Pampori UI 0.330 0.750 1.430 1. 7. SH-C-1154 x Kashmir Long-1 UI 0.210 0.680 1.720 1. 8. <td< td=""><td></td><td></td><td></td><td>Ι</td><td></td><td>0.28</td><td>0.45</td><td></td></td<>				Ι		0.28	0.45	
1. Arka Lohit x Kashmir Long-1 UI 0.220 0.740 1.790 $1.$ I 0.700 1.740 $1.$ 2. Arka Lohit x Local Chilli UI 0.250 0.670 1.050 $0.$ 3. Arka Lohit x SH-C-101 UI 0.270 0.960 1.620 $1.$ 4. Arka Lohit x SH-PC-1 UI 0.440 1.020 1.920 $1.$ 4. Arka Lohit x SH-PC-1 UI 0.440 1.020 1.920 $1.$ 5. Arka Lohit x SH-C-405 UI 0.550 1.100 1.940 $1.$ 5. Arka Lohit x SH-C-405 UI 0.330 0.750 1.430 $1.$ 6. Arka Lohit x Pampori UI 0.210 0.680 1.720 $1.$ 7. SH-C-1154 x Kashmir Long-1 UI 0.230 0.590 1.000 $0.$ 8. SH-C-1154 x SH-C-101 UI 0.220 0.870 1.650 $1.$ 10. SH-C-1154 x SH-PC-1 UI 0.390		Hybrids						
I 0.700 1.740 $1.$ 2.Arka Lohit x Local ChilliUI 0.250 0.670 1.050 $0.$ 3.Arka Lohit x SH-C-101UI 0.270 0.960 1.620 $1.$ 4.Arka Lohit x SH-PC-1UI 0.440 1.020 1.920 $1.$ 5.Arka Lohit x SH-C-405UI 0.550 1.100 1.940 $1.$ 5.Arka Lohit x SH-C-405UI 0.550 1.100 1.940 $1.$ 6.Arka Lohit x PamporiUI 0.330 0.750 1.430 $1.$ 7.SH-C-1154 x Kashmir Long-1UI 0.210 0.680 1.720 $1.$ 8.SH-C-1154 x SH-C-101UI 0.230 0.590 1.000 $0.$ 9.SH-C-1154 x SH-C-101UI 0.220 0.870 1.650 $1.$ 10.SH-C-1154 x SH-C-101UI 0.390 0.920 1.490 $1.$ 11.SH-C-1154 x SH-C-101UI 0.390 0.920 1.490 $1.$	1.	Arka Lohit x Kashmir Long-1		UI	0.220	0.740	1.790	1.265
2. Arka Lohit x Local Chilli UI 0.250 0.670 1.050 $0.$ 1 0.650 1.100 $0.$ 3. Arka Lohit x SH-C-101 UI 0.270 0.960 1.620 $1.$ 4. Arka Lohit x SH-PC-1 UI 0.440 1.020 1.920 $1.$ 5. Arka Lohit x SH-C-405 UI 0.550 1.100 1.940 $1.$ 5. Arka Lohit x SH-C-405 UI 0.550 1.100 1.940 $1.$ 6. Arka Lohit x Pampori UI 0.330 0.750 1.430 $1.$ 7. SH-C-1154 x Kashmir Long-1 UI 0.210 0.680 1.720 $1.$ 8. SH-C-1154 x Local Chilli UI 0.230 0.590 1.000 $0.$ 9. SH-C-1154 x SH-C-101 UI 0.220 0.870 1.650 $1.$ 10. SH-C-1154 x SH-PC-1 UI 0.390 0.920 1.490 $1.$ 11. SH-C-1154 x SH-PC-405 UI 0.390 <				Ι		0.700	1.740	1.220
I 0.650 1.100 $0.$ 3.Arka Lohit x SH-C-101UI 0.270 0.960 1.620 $1.$ 4.Arka Lohit x SH-PC-1UI 0.440 1.020 1.920 $1.$ 5.Arka Lohit x SH-C-405UI 0.550 1.100 1.940 $1.$ 5.Arka Lohit x SH-C-405UI 0.550 1.100 1.940 $1.$ 6.Arka Lohit x PamporiUI 0.330 0.750 1.430 $1.$ 7.SH-C-1154 x Kashmir Long-1UI 0.210 0.680 1.720 $1.$ 8.SH-C-1154 x Local ChilliUI 0.230 0.590 1.000 $0.$ 9.SH-C-1154 x SH-C-101UI 0.220 0.870 1.650 $1.$ 10.SH-C-1154 x SH-PC-1UI 0.390 0.920 1.490 $1.$ 11.SH-C-1154 x SH-PC-1UI 0.390 0.920 1.490 $1.$	2.	Arka Lohit x Local Chilli		UI	0.250	0.670	1.050	0.860
3. Arka Lohit x SH-C-101 UI 0.270 0.960 1.620 $1.$ 4. Arka Lohit x SH-PC-1 UI 0.440 1.020 1.920 $1.$ 5. Arka Lohit x SH-C-405 UI 0.440 1.020 1.940 $1.$ 5. Arka Lohit x SH-C-405 UI 0.550 1.100 1.960 $1.$ 6. Arka Lohit x Pampori UI 0.330 0.750 1.430 $1.$ 7. SH-C-1154 x Kashmir Long-1 UI 0.210 0.680 1.720 $1.$ 8. SH-C-1154 x Local Chilli UI 0.230 0.590 1.000 0.700 $1.$ 9. SH-C-1154 x SH-C-101 UI 0.230 0.590 1.000 0.700 $1.$ 10. SH-C-1154 x SH-C-101 UI 0.220 0.870 1.650 $1.$ 10. SH-C-1154 x SH-PC-1 UI 0.390 0.920 1.440 $1.$ 11. SH-C-1154 x SH-C-405 UI 0.450 0.990 1.330 $1.$				Ι		0.650	1.100	0.875
I 0.930 1.650 $1.$ 4.Arka Lohit x SH-PC-1UI 0.440 1.020 1.920 $1.$ 5.Arka Lohit x SH-C-405UI 0.550 1.100 1.940 $1.$ 6.Arka Lohit x PamporiUI 0.330 0.750 1.430 $1.$ 7.SH-C-1154 x Kashmir Long-1UI 0.210 0.680 1.720 $1.$ 8.SH-C-1154 x Local ChilliUI 0.230 0.590 1.000 $0.$ 9.SH-C-1154 x SH-C-101UI 0.220 0.870 1.650 $1.$ 10.SH-C-1154 x SH-C-1UI 0.390 0.920 1.440 $1.$ 11.SH-C-1154 x SH-C-1UI 0.390 0.920 1.440 $1.$	3.	Arka Lohit x SH-C-101		UI	0.270	0.960	1.620	1.290
4. Arka Lohit x SH-PC-1 UI 0.440 1.020 1.920 1. I I 1.000 1.940 1. 5. Arka Lohit x SH-C-405 UI 0.550 1.100 1.960 1. I 1.210 1.990 1. 1.210 1.990 1. 6. Arka Lohit x Pampori UI 0.330 0.750 1.430 1. 7. SH-C-1154 x Kashmir Long-1 UI 0.210 0.680 1.720 1. 7. SH-C-1154 x Local Chilli UI 0.230 0.590 1.000 0. 8. SH-C-1154 x SH-C-101 UI 0.220 0.870 1.650 1. 9. SH-C-1154 x SH-C-101 UI 0.220 0.870 1.650 1. 10. SH-C-1154 x SH-C-101 UI 0.390 0.920 1.490 1. 11. SH-C-1154 x SH-C-405 UI 0.450 0.990 1.330 1				Ι		0.930	1.650	1.290
I1.0001.9401.5.Arka Lohit x SH-C-405UI0.5501.1001.9601.I1.2101.9901.1.1.2101.9901.6.Arka Lohit x PamporiUI0.3300.7501.4301.7.SH-C-1154 x Kashmir Long-1UI0.2100.6801.7201.7.SH-C-1154 x Local ChilliUI0.2300.5901.0000.8.SH-C-1154 x Local ChilliUI0.2300.5901.0000.9.SH-C-1154 x SH-C-101UI0.2200.8701.6501.10.SH-C-1154 x SH-C-101UI0.3900.9201.4901.11.SH-C-1154 x SH-C-105UI0.4500.9901.3301	4.	Arka Lohit x SH-PC-1		UI	0.440	1.020	1.920	1.500
5. Arka Lohit x SH-C-405 UI 0.550 1.100 1.960 $1.$ 6. Arka Lohit x Pampori UI 0.330 0.750 1.430 $1.$ 7. SH-C-1154 x Kashmir Long-1 UI 0.210 0.680 1.720 $1.$ 7. SH-C-1154 x Local Chilli UI 0.210 0.680 1.720 $1.$ 8. SH-C-1154 x Local Chilli UI 0.230 0.590 1.000 $0.$ 9. SH-C-1154 x SH-C-101 UI 0.220 0.870 1.650 $1.$ 10. SH-C-1154 x SH-C-101 UI 0.390 0.920 1.490 $1.$ 11. SH-C-1154 x SH-C-101 UI 0.390 0.920 1.490 $1.$ 10. SH-C-1154 x SH-PC-1 UI 0.390 0.920 1.490 $1.$ 11. SH-C-1154 x SH-C-405 UI 0.450 0.990 1.330 1.50				Ι		1.000	1.940	1.470
I1.2101.9901.6.Arka Lohit x PamporiUI0.3300.7501.4301.II0.8001.5101.7.SH-C-1154 x Kashmir Long-1UI0.2100.6801.7201.I0.6901.7001.1.1.1.8.SH-C-1154 x Local ChilliUI0.2300.5901.0000.9.SH-C-1154 x SH-C-101UI0.2200.8701.6501.10.SH-C-1154 x SH-PC-1UI0.3900.9201.4901.11.SH-C-1154 x SH-C-405UI0.4500.9901.3301	5.	Arka Lohit x SH-C-405		UI	0.550	1.100	1.960	1.530
				Ι		1.210	1.990	1.600
I 0.800 1.510 $1.$ 7.SH-C-1154 x Kashmir Long-1UI 0.210 0.680 1.720 $1.$ I0.690 1.700 $1.$ 8.SH-C-1154 x Local ChilliUI 0.230 0.590 1.000 $0.$ 9.SH-C-1154 x SH-C-101UI 0.220 0.870 1.650 $1.$ 10.SH-C-1154 x SH-PC-1UI 0.390 0.920 1.490 $1.$ 11.SH-C-1154 x SH-C-405UI 0.450 0.990 1.330 $1.$	6.	Arka Lohit x Pampori		UI	0.330	0.750	1.430	1.090
7. SH-C-1154 x Kashmir Long-1 UI 0.210 0.680 1.720 1. I I 0.690 1.700 1. 8. SH-C-1154 x Local Chilli UI 0.230 0.590 1.000 0. I 0.540 1.020 0. 0. 0. 0.540 1.020 0. 9. SH-C-1154 x SH-C-101 UI 0.220 0.870 1.650 1. 10. SH-C-1154 x SH-PC-1 UI 0.390 0.920 1.490 1. 11. SH-C-1154 x SH-C-405 UI 0.450 0.990 1.330 1				Ι		0.800	1.510	1.155
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	7.	SH-C-1154 x Kashmir Long-1		UI	0.210	0.680	1.720	1.200
8. SH-C-1154 x Local Chilli UI 0.230 0.590 1.000 0. I 0.540 1.020 0. 9. SH-C-1154 x SH-C-101 UI 0.220 0.870 1.650 1. 10. SH-C-1154 x SH-PC-1 UI 0.390 0.920 1.440 1. 11. SH-C-1154 x SH-C-405 UI 0.450 0.990 1.330 1				Ι		0.690	1.700	1.195
I 0.540 1.020 0. 9. SH-C-1154 x SH-C-101 UI 0.220 0.870 1.650 1. I 0.820 1.640 1. 10. SH-C-1154 x SH-PC-1 UI 0.390 0.920 1.490 1. I 0.900 1.470 1. 1. 11. SH-C-1154 x SH-C-405 UI 0.450 0.990 1.330 1	8.	SH-C-1154 x Local Chilli		UI	0.230	0.590	1.000	0.795
9. SH-C-1154 x SH-C-101 UI 0.220 0.870 1.650 1. I 0.820 1.640 1. 10. SH-C-1154 x SH-PC-1 UI 0.390 0.920 1.490 1. I 0.900 1.470 1. 11. SH-C-1154 x SH-C-405 UI 0.450 0.990 1 330 1				I 		0.540	1.020	0.780
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	9.	SH-C-1154 x SH-C-101		UI	0.220	0.870	1.650	1.260
10. SH-C-1154 x SH-PC-1 UI 0.390 0.920 1.490 1. I 0.900 1.470 1. 11. SH-C-1154 x SH-C-405 UI 0.450 0.990 1 330 1	10			l	0.000	0.820	1.640	1.230
I 0.900 1.470 1. 11. SH-C-1154 x SH-C-405 UI 0.450 0.990 1.330 1	10.	SH-C-1154 x SH-PC-1		UI	0.390	0.920	1.490	1.205
T1. SH-C-1154 x SH-C-405 UI 0.450 0.990 1.330 1				1	0.450	0.900	1.470	1.185
	11.	SH-C-1154 x SH-C-405		UI	0.450	0.990	1.330	1.160
I 0.930 1.310 1.				l		0.930	1.310	1.120
12. SH-C-1154 x Pampori UI 0.300 0.930 1.070 1.	12.	SH-C-1154 x Pampori		UI	0.300	0.930	1.070	1.000
I 0.900 1.050 0.4				I		0.900	1.050	0.975
UI 0.32 0.85 1.50				UI	0.32	0.85	1.50	
Means I 0.84 1.55			Means	Ι		0.84	1.55	

Table 2. Orthodihydroxy phenol concentration (mg/g) in un-inoculated/inoculated chilli genotypes at different stages

LSD = Genotypes (0.035***), Stage (0.011***), Inoculation (0.011***), Genotype x Stage (0.050***), Genotype x Inoculation (0.050***), Stage x Inoculation (0.016***), Genotype x Stage x Inoculation (0.071***)

Resistant parents 1. Arka Lohit UI 0.160 3.040 3.520 5.200 3.920 2. SH-C-1154 UI 0.160 3.400 5.150 4.760 2. SH-C-1154 UI 0.120 2.860 3.440 5.150 4.770 2. SH-C-1154 UI 0.140 2.860 3.480 5.130 3. SH-C-1154 UI 0.140 2.860 3.480 5.130 2. Susceptible parents I 4.480 4.220 5.230 3.533 3. SH-C-1-01 UI 0.060 2.860 3.480 4.590 3.533 4. SH-PC-1 UI 0.020 2.470 3.350 4.180 3.333 5. SH-C-405 UI 0.020 2.460 3.440 0.300 1.283 5. SH-C-405 UI 0.020 2.460 3.240 4.130 3.277 Means UI	S. No.	Genotype	Uninocula Inoculated	ted/	Stage 1	Stage 2	Stage 3	Stage 4	Mean
1. Arka Lohit UI 0.160 3.940 3.520 5.200 3.920 2. SH-C-1154 II 4.200 4.210 5.160 3.727 I 0.100 0.280 2.860 3.440 5.060 3.727 I 0.100 0.140 2.860 3.440 5.200 4.517 Susceptible parents I 0.140 2.860 3.430 5.300 4.537 2. Pampori II 0.080 2.920 3.210 4.200 3.433 3. SH-C-1-01 II 0.060 2.860 3.440 0.000 1.280 3. SH-C-1-01 II 0.020 2.470 3.530 4.580 3.033 3. SH-C-1-05 II 0.200 2.470 3.500 4.580 3.237 5. SH-C-1-05 II 0.200 2.460 3.240 4.130 3.237 5. SH-C-105 II 0.200 2.450 3.200 1.201 6. Local Challi II 0.202		Resistant parents	inoculatea						
Indication Instruction Instruction <thinstruction< th=""> <thinstruction< th=""></thinstruction<></thinstruction<>	1	Arka Lohit		Ш	0.160	3 040	3 520	5 200	3 920
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	1.			I	0.100	4 920	4 210	5 150	4 760
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	2	SH-C-1154		I II	0.120	2 680	3 4 4 0	5.060	3 727
Mean UI 0.140 260 3.40 5.130 I 4.200 5.200 Susceptible parents 1 1.80 1.420 5.330 1 1.80 1.540 0.000 0.873 2 Pampori 1 1.800 1.540 0.000 1.230 3. SH-C-1-01 1 0.060 2.800 3.240 3.960 3.983 4. SH-C-1-01 UI 0.020 2.470 3.350 4.180 3.233 5. SH-C-1-01 UI 0.020 2.350 3.050 4.250 3.217 6. SH-C-405 UI 0.020 2.470 3.350 4.180 3.233 5. SH-C-405 UI 0.020 2.460 3.260 4.250 3.217 6. Local Chilli UI 0.020 2.460 3.600 5.50 4.001 7 Heard UI 0.020 2.400 3.60 3.500 </td <td></td> <td></td> <td></td> <td>I</td> <td>0.120</td> <td>4 030</td> <td>4 220</td> <td>5 300</td> <td>4 517</td>				I	0.120	4 030	4 220	5 300	4 517
Interm			Means	т П	0 140	2 860	3 480	5 130	1017
Susceptible parents Intermediate of the second secon			Wieuno	I	0.110	4 480	4 220	5 230	
1. Kashmir Long-I I 0.080 2.920 3.210 4.200 3.431 2. Pampori I 0.000 2.560 3.540 4.590 3.533 3. SH-C-1-01 UI 0.060 2.680 3.240 3.960 3.933 4. SH-PC-1 UI 0.020 2.470 3.350 4.180 3.333 5. SH-C-405 I 0.202 2.460 3.240 3.232 3.217 5. SH-C-405 UI 0.020 2.460 3.230 4.180 3.333 6. Local Chilli UI 0.020 2.460 3.240 3.277 7 I 1.330 1.480 0.000 0.937 7 Means UI 0.402 2.460 3.200 4.200 6. Local Chilli UI 0.600 3.560 4.220 4.201 7 Means UI 0.600 3.560 3.840 5.200 4.201 7 Arka Lohit x Local Chilli I 0.500 3.		Susceptible parents		-					
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	1.	Kashmir Long-1		UI	0.080	2.920	3.210	4.200	3.443
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		0		I		1.080	1.540	0.000	0.873
I I 1920 1950 0.000 1290 3. SH-C1-01 UI 0.060 2.080 3.240 3.960 3.093 4. SH-PC-1 I 1.120 1.440 0.000 0.853 5. SH-C405 UI 0.020 2.350 3.050 4.250 3.217 6. Local Chilli UI 0.020 2.360 3.240 4.130 3.277 1 1.450 1.670 0.000 1.040 6.000 0.937 6. Local Chilli UI 0.020 2.460 3.240 4.130 3.277 1 1.460 1.660 0.000 1.040 6.60 0.000 1 1.460 1.660 0.000 1.040 1.60 1.020 1 1.460 1.660 0.000 1.041 1.60 3.60 3.840 5.40 4.000 1 3.840	2.	Pampori		UI	0.060	2.560	3.450	4.590	3.533
3. SH-C-1-01 II 0.060 2.080 3.240 3.960 3.093 4. SH-PC-1 II 0.020 2.470 3.350 4.180 3.351 5. SH-C-405 II 0.020 2.350 3.050 4.250 3.217 6. Local Chilli II 0.020 2.460 3.240 4.130 3.277 6. Local Chilli 0.020 2.460 3.240 4.130 3.277 1 1.300 1.480 0.000 0.937 1.120 1.480 0.000 0.937 6. Local Chilli II 0.040 2.470 3.260 4.20 4.130 3.277 1 Hybrids II 0.400 2.470 3.260 4.201 4.001 4.001 4.001 4.001 4.001 4.001 4.001 4.001 4.001 4.001 4.001 4.001 4.001 4.001 4.001 4.001 5.01 4.001 4.001 5.01 4.001 4.001 5.01 4.001 5.01 4.011 4.011 <td></td> <td>1</td> <td></td> <td>Ι</td> <td></td> <td>1.920</td> <td>1.950</td> <td>0.000</td> <td>1.290</td>		1		Ι		1.920	1.950	0.000	1.290
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	3.	SH-C-1-01		UI	0.060	2.080	3.240	3.960	3.093
4. SH-PC-1 UI 0.020 2.470 3.350 4.180 3.333 5. SH-C-405 I 0.000 2.350 3.050 4.250 3.217 6. Local Chilli I 0.020 2.460 3.240 4.130 3.277 6. Local Chilli UI 0.020 2.460 3.240 4.130 3.277 7 I 1.330 1.460 0.000 0.937 1.167 0.000 0.937 7 Means UI 0.040 2.460 3.260 4.200 1.167 7 Arka Lohit Kashmir Long- I 1.460 1.660 0.000 1.167 8 Arka Lohit X Local Chilli I 1.460 3.600 5.560 4.001 3. Arka Lohit x SH-C-101 II 0.500 3.560 3.840 5.120 4.570 4. Arka Lohit x SH-C-101 II 0.500 2.640 3.840 5.301 3.917 <				Ι		1.120	1.440	0.000	0.853
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	4.	SH-PC-1		UI	0.020	2.470	3.350	4.180	3.333
5. SH-C-405 UI 0.020 2.350 3.050 4.250 3.217 6. Local Chilli UI 0.020 2.460 3.240 4.130 3.277 6. Local Chilli UI 0.040 2.470 3.260 4.220 9.307 1 1.460 1.660 0.000 9.377 9.360 4.260 9.360 1 0.440 2.470 3.260 4.220 4.200 9.360 4.260 9.360 9.360 4.360 9.360 4.360				Ι		1.860	1.900	0.000	1.253
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	5.	SH-C-405		UI	0.020	2.350	3.050	4.250	3.217
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$				Ι		1.450	1.670	0.000	1.040
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	6.	Local Chilli		UI	0.020	2.460	3.240	4.130	3.277
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$				Ι		1.330	1.480	0.000	0.937
III.460I.6600.000Hybrids10.8602.8403.6005.5604.000110.8602.8403.6005.5604.000110.8003.5603.8405.2024.2072Arka Lohit x Local ChilliUI0.5302.5603.8805.3103.9173Arka Lohit x SH-C-101UI0.5302.5603.8805.3103.9174Arka Lohit x SH-C-101UI0.9902.4403.8405.4703.9175Arka Lohit x SH-C-105I3.2002.6003.3205.1004.6435Arka Lohit x SH-C-405UI0.9002.4403.8405.4703.7036Arka Lohit x PamporiUI0.9603.0403.4005.3403.9277SH-C-1154 x Kashmir Long-1UI0.65.02.5603.2805.1103.6008SH-C-1154 x Local ChilliI0.52.02.6403.4805.6003.7278SH-C-1154 x SH-C-101UI0.5102.2003.9205.2403.7871SH-C-1154 x SH-C-101UI0.6102.2003.9205.2403.7871SH-C-1154 x SH-C-101UI0.6102.2003.2405.3303.7971SH-C-1154 x SH-C-101UI0.6102.8003.2405.3303.7971SH-C-1154 x SH-C-105II0.6102.8003.240<			Means	UI	0.040	2.470	3.260	4.220	
Hybrids 1. Arka Lohit x Kashmir Long-1 II 0.860 2.840 3.600 5.560 4.000 1 I 0.860 2.840 3.600 5.560 4.563 2. Arka Lohit x Local Chilli II 0.600 3.840 4.400 5.450 4.900 3. Arka Lohit x SH-C-101 II 0.530 2.560 3.880 5.310 3.917 4. Arka Lohit x SH-C-101 II 0.530 2.440 3.840 5.470 3.917 4. Arka Lohit x SH-C-101 II 0.990 2.440 3.840 5.470 3.917 5. Arka Lohit x SH-C-405 II 0.900 2.440 3.840 5.470 3.917 6. Arka Lohit x SH-C-405 II 0.600 3.320 4.640 5.300 4.640 7. SH-C-1154 x Kashmir Long-1 II 0.650 2.560 3.280 5.110 3.650 8. SH-C-1154 x Sh-C-101 II 0.610 <td></td> <td></td> <td></td> <td>Ι</td> <td></td> <td>1.460</td> <td>1.660</td> <td>0.000</td> <td></td>				Ι		1.460	1.660	0.000	
1. Arka Lohit x Kashmir Long-1 UI 0.860 2.840 3.600 5.560 4.000 1 I 3840 4.400 5.450 4.563 2. Arka Lohit x Local Chilli UI 0.690 3.560 3.840 5.220 4.207 I 4.640 4.990 5.070 4.900 3. Arka Lohit x SH-C-101 UI 0.530 2.560 3.880 5.310 3.917 I 3.400 5.150 5.120 4.570 4. Arka Lohit x SH-C-101 UI 0.990 2.440 3.840 5.470 3.917 I 3.210 4.640 5.360 4.403 5.470 3.917 I 3.210 4.640 5.360 4.403 5.40 3.703 I 0.630 2.600 3.320 5.190 3.703 I 3.800 5.400 5.340 3.927 I 3.800 5.400 5.340 3.927 I 3.500 4.400 5.300 4.433 5. <t< td=""><td></td><td>Hybrids</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>		Hybrids							
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	1.	Arka Lohit x Kashmir Long-		UI	0.860	2.840	3.600	5.560	4.000
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		1		Ι		3.840	4.400	5.450	4.563
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	2.	Arka Lohit x Local Chilli		UI	0.690	3.560	3.840	5.220	4.207
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$				Ι		4.640	4.990	5.070	4.900
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	3.	Arka Lohit x SH-C-101		UI	0.530	2.560	3.880	5.310	3.917
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$				Ι		3.440	5.150	5.120	4.570
Image: state of the sta	4.	Arka Lohit x SH-PC-1		UI	0.990	2.440	3.840	5.470	3.917
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$				Ι		3.210	4.640	5.360	4.403
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	5.	Arka Lohit x SH-C-405		UI	0.630	2.600	3.320	5.190	3.703
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$				Ι		3.990	4.440	5.000	4.463
I 3.580 4.440 5.320 4.433 7. SH-C-1154 x Kashmir Long-1 UI 0.65.0 2.560 3.280 5.110 3.650 I 3.410 3.800 5.140 4.117 8. SH-C-1154 x Local Chilli UI 0.52.0 2.640 3.480 5.060 3.727 I 0.610 2.200 3.920 5.240 3.787 I 0.610 2.800 3.240 5.140 4.113 10. SH-C-1154 x SH-PC-1 UI 0.470 2.280 3.240 5.110 3.543 11. SH-C-1154 x SH-C-405 UI 0.470 2.880 3.600 5.330 3.937	6.	Arka Lohit x Pampori		UI	0.960	3.040	3.400	5.340	3.927
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		-		Ι		3.580	4.440	5.320	4.433
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	7.	SH-C-1154 x Kashmir Long-1		UI	0.65.0	2.560	3.280	5.110	3.650
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		U		Ι		3.410	3.800	5.140	4.117
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	8.	SH-C-1154 x Local Chilli		UI	0.52.0	2.640	3.480	5.060	3.727
$\begin{array}{cccccccccccccccccccccccccccccccccccc$				Ι		3.040	4.000	5.080	4.040
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	9.	SH-C-1154 x SH-C-101		UI	0.610	2.200	3.920	5.240	3.787
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$				Ι		3.160	4.040	5.140	4.113
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	10.	SH-C-1154 x SH-PC-1		UI	0.530	2.800	3.240	5.330	3.790
11. SH-C-1154 x SH-C-405 UI 0.470 2.280 3.240 5.110 3.543 I 3.330 4.080 5.210 4.207 12. SH-C-1154 x Pampori UI 0.640 2.880 3.600 5.330 3.937 I 3.160 4.080 5.630 4.290 Means UI 0.670 2.700 3.550 5.270				Ι		3.440	4.200	5.200	4.280
I2. SH-C-1154 x Pampori I 3.330 4.080 5.210 4.207 I2. SH-C-1154 x Pampori UI 0.640 2.880 3.600 5.330 3.937 I 3.160 4.080 5.630 4.290 Means UI 0.670 2.700 3.550 5.270 I 3.520 4.360 5 230 5.230	11.	SH-C-1154 x SH-C-405		UI	0.470	2.280	3.240	5.110	3.543
12. SH-C-1154 x Pampori UI 0.640 2.880 3.600 5.330 3.937 I 3.160 4.080 5.630 4.290 Means UI 0.670 2.700 3.550 5.270 I 3.520 4.360 5 230				Ι		3.330	4.080	5.210	4.207
I 3.160 4.080 5.630 4.290 Means UI 0.670 2.700 3.550 5.270 I 3.520 4.360 5.230	12.	SH-C-1154 x Pampori		UI	0.640	2.880	3.600	5.330	3.937
MeansUI0.6702.7003.5505.270I3.5204.3605.230		ł		Ι		3.160	4.080	5.630	4.290
I 3.520 4.360 5.230			Means	UI	0.670	2.700	3.550	5.270	
- 0.010 0.0100				Ι		3.520	4.360	5.230	

Table 3: Polyphenol oxidase activity (units/minute) in un-inoculated/inoculated chilli genotypes at different stages.

LSD= Genotypes (0.027^{***}), Stage (0.10^{**}), Inoculation (0.008^{***}), Genotype x Stage (0.046^{***}), Genotype x Inoculation (0.038^{***}), Stage x Inoculation (0.014^{***}), Genotype x Stage x Inoculation (0.065^{***})

S. No.	Genotype	Uninocul Inoculate	lated/ ed	Stage 1	Stage 2	Stage 3	Stage 4	Mean
	Resistant parents							
1.	Arka Lohit		UI	0.700	0.900	3.450	16.450	6.933
			Ι	-	0.890	3.250	16.900	7.013
2.	SH-C-1154		UI	0.650	0.950	3.230	15.010	6.397
			Ι	-	0.820	3.150	15.453	6.474
		Means	UI	0.680	0.930	3.340	15.370	
			Ι		0.860	3.200	16.170	
	Susceptible parents							
1.	Kashmir Long-1		UI	0.700	0.920	2.990	9.300	4.403
			Ι	-	1.830	3.990	0.000	1.940
2.	Pampori		UI	0.680	0.800	3.410	8.200	4.403
			Ι	-	1.950	3.990	0.000	1.940
3.	SH-C-101		UI	0.700	1.100	4.020	9.700	4.940
			Ι	-	2.250	4.700	0.000	2.317
4.	SH-PC-1		UI	0.450	0.950	2.820	7.200	3.657
			Ι	-	2.100	3.960	0.000	2.020
5.	SH-C-405		UI	0.550	8.830	3.010	8.420	4.087
			Ι	-	2.990	3.680	0.000	2.223
6.	Local Chilli		UI	0.770	0.850	3.780	8.330	4.320
			Ι	-	2.920	3.647	0.000	2.189
		Means	UI	0.640	0.910	3.340	8.530	
			Ι		2.340	3.990	0.000	
	Hybrids							
1.	Arka Lohit x Kashmir Long-1		UI	3.750	5.500	6.540	14.500	8.847
			Ι	-	6.800	7.420	14.590	9.603
2.	Arka Lohit x Local Chilli		UI	3.200	4.000	7.050	15.210	8.753
			Ι	-	5.250	8.350	15.290	9.630
3.	Arka Lohit x SH-C-101		UI	3.000	3.550	6.800	18.530	9.627
			Ι	-	5.100	8.450	18.710	10.753
4.	Arka Lohit x SH-PC-1		UI	2.850	3.550	5.740	16.740	8.677
			Ι	-	5.100	6.350	16.900	9.250
5.	Arka Lohit x SH-C-405		UI	3.350	3.600	5.020	19.420	9.347
			Ι	-	4.000	6150	19.530	9.893
6.	Arka Lohit x Pampori		UI	3.500	4.300	5.050	15.200	8.183
			Ι	-	5.950	8.000	15.220	9.723
7.	SH-C-1154 x Kashmir Long-1		UI	3.050	3.500	5.260	13.310	7.357
			Ι	-	4.580	7.040	13.370	8.330
8.	SH-C-1154 x Local Chilli		UI	3.250	4.050	6.740	14.730	8.507
			Ι	-	5.230	8.850	14.810	9.730
9.	SH-C-1154 x SH-C-101		UI	2.120	3.100	5.850	16.850	8.600
			Ι	-	5.230	7.850	16.900	9.993
10.	SH-C-1154 x SH-PC-1		UI	3.320	3.920	5.280	15.410	8.203
			Ι	-	4.880	6.690	15.480	9.009
11.	SH-C-1154 x SH-C-405		UI	3.050	3.620	5.050	15.440	8.037
			Ι	-	4.880	6.690	15.480	9.017
12.	SH-C-1154 x Pampori		UI	3.000	3.340	5.950	15.410	8.233
	-		Ι	-	4.720	6.800	15.420	8.980
		Means	UI	3.120	3.840	5.860	15.900	
			T		5 1 9 0	7 390	15 980	
			1		5.190	1.590	10.700	

Table-4: Peroxidase activity in un-inoculated/inoculated chilli genotypes at different stages (units/minute)

LSD= Genotypes (0.038^{***}), Stage (0.014^{**}), Inoculation (0.012^{***}), Genotype x Stage (0.066^{***}), Genotype x Inoculation (0.054^{***}), Stage x Inoculation (0.020^{***}), Genotype x Stage x Inoculation (0.093^{***})

From the biochemical results it can be concluded that there is a positive correlation between host resistance and the amount of phenols and increased enzyme activity. The opposite occurs in the susceptible plants. The positive association of higher phenols and enzyme activity with resistance could be of value for early identification of resistant genotypes during population screening.

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