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IDENTIFICATION OF HIGH TEMPERATURE TOLERANT GENOTYPES UNDER SHADE HOUSE CONDITION AND GENETIC PARAMETER STUDIES IN CHILLI (*CAPSICUM ANNUUM* L.)

Pruthviraj, G.*, Tembhurne, B.V., Lokesh, G.Y., Rajanna, B. and Meena, M.K.

Department of Genetics and Plant Breeding, College of Agriculture, Raichur, University of Agricultural Sciences, Raichur, Karnataka, India.
*Corresponding author E-mail: pruthvireddy5531@gmail.com
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ABSTRACT

A study was conducted to identify high temperature tolerant genotypes of chilli under shade house condition during summer season 2021-22. Twenty-four genotypes were grown inside and outside the shade house with 50 per cent shade. Complete mortality was observed in case of the seedlings transplanted outside the shade net house due to heat shock. However, 90 per cent seedlings survived with 10 per cent mortality inside the shade net. Hence, the plants under the shade house were considered for further studies to identify the high temperature tolerant genotypes. The characters like plant height, plant spread, number of primary branches, number of secondary branches, pollen viability, fruit length, fruit weight, total leaf area, relative water content, total dry matter and average fruit yield per plant were affected. However, higher level of physiological and biochemical parameters like stomatal conductance, total chlorophyll content and leaf proline content were noticed. While, quality traits like oleoresin and capsaicin content showed variable response under heat stress condition. Genotypes *viz*., HYIB-13-2-U followed by JNB-1, Raichur bullet-1 and UARChH-42-F_3-2, were found to be temperature tolerant. Whereas, Byadgi dabbi-S, RAWE-UP, H-short registered high sensitivity to heat stress. High heritability coupled with high percent mean genetic advance was observed for characters like plant height, plant spread, number of primary branches, number of secondary branches, days to first flower bud initiation, pollen viability, fruit length, fruit weight, total leaf area, stomatal conductance, total dry matter, total chlorophyll content, leaf proline content, capsaicin content, oleoresin content and average fruit yield per plant.

***Key words*:** Chilli, Genetic parameters, Shade, Stress and Temperature tolerant.

Introduction

Chilli (*Capsicum annuum* L.), also called hot red pepper, is an important cash crop in India and is grown for its pungent fruits. Chilli is often cross-pollinated crop and frequency of cross pollination in the field range from 7 per cent to as high as 36 per cent. The pungency is due to active principle ‘Capsaicin’ contained in the placenta of fruit which has diverse prophylactic and therapeutic uses in allopathic and ayurvedic medicine. It is also a good source of chilli oleoresin, which is the total flavour extract of dried and ground chilies and concentration in homogenous free flowing product, which has varied uses in processed food and beverage industries. The natural colour extracts of chilli are also finding their increased value in place of artificial colors in the food items, especially in the developed nations. In India, red chilli is cultivated in an area of 0.623 million hectares with a production of 1.841 million tonnes and productivity of 2954 kg per hectare. Hot pepper requires comparatively a longer growing period of 130-150 days and fruit setting is drastically reduced if dry weather is accompanied by high temperature. Flower abscission will be high if day temperature is in the range of 32-38°C. Whereas, fruit retention will be maximal at 16-21°C during day

Table 1: List of genotypes included in the present study.

Sl. No.	Genotypes
1.	UARChH-42-F_3-1
2.	HYIB-13-1
3.	Raichur bullet - ML
4.	Rajput yellow
5.	Byadgi dabbi
6.	Sitara
7.	UARChH-42
8.	G-4-L
9.	HYIB-13-4
10.	Raichur Bullet
11.	BVC-42
12.	HYIB-13-2-U
13.	Raichur - L
14.	HYIB-13-2
15.	JNB-1
16.	HYIB-13-3
17.	UARChH-42-F_3-2
18.	Raichur Bullet-1
19.	UARChH-43
20.	RAWE-UP
21.	H-short
22.	ACB-1
23.	Guntur
24.	Byadgi dabbi - S

temperature. As compared to other crops, chilli plants do not appear to suffer from leaf injury and grow normally even under continuous light (Demers *et al.,* 1994 and Murage *et al.,* 1994).

High temperature affects several physiological and biochemical processes of the plant leading to impaired growth and reproduction; shorten life cycle by hastening flowering and maturity, reduced yield and production of poor-quality fruits. High temperature induced decrease in crop yield has been closely linked to damaged thylakoid membranes, decreased chlorophyll content and increased membrane leakage. Cell membrane thermo stability has been found to be a useful physiological parameter for selection of heat tolerant genotypes in *Capsicum annuum* and *Capsicum fructescens*. Thus, present study was undertaken to screen genotypes for tolerance to high temperature under shade house condition through morphological and yield parameters and to study physiological and biochemical mechanisms at high temperature.

Material and Methods

The experiment was conducted at experimental farm, Department of Genetics and Plant Breeding and Laboratory, College of Agriculture Raichur during the year 2021-22. The experimental materials for the present study comprises of 24 genotypes (including hybrids and advanced breeding lines) with different genetic background. The genotypes were selected based on the earlier performance for tolerance to high temperature. The genotypes included in the study are given in Table 1. The chilli seedlings were transplanted on February first week 2022 and subjected to hot summer in the shade house preparing raised beds and using Randomized Complete Block Design with two replications and spacing of 60cm × 45 cm.

The data was recorded on four plants per genotype and was averaged for use in statistical analysis for the traits *viz*., plant height, plant spread, number of primary branches, number of secondary branches, days to first flower bud initiation, days to 50 per cent flowering and days to first fruit picking. However, average dry fruit yield per plant, fruit length and fruit weight were taken from randomly selected five fruits per genotype in each replication. Pollen viability was studied through iodine-potassium iodide (0.44 g iodine + 20.8 g potassium iodide in 500 ml of 70% alcohol) staining technique. The viable pollen stained immediately dark blue and non-viable ones remained as light yellow. The number of viable and non-viable pollens were counted using microscope. The viability percentage was calculated as the ratio of number of viable pollen grains to the total number of pollen grains for each genotype, Jensen (1962). The leaf area per plant was worked out on dry weight basis as per Vivekanandan *et al.*, (1972). Relative water content was estimated by

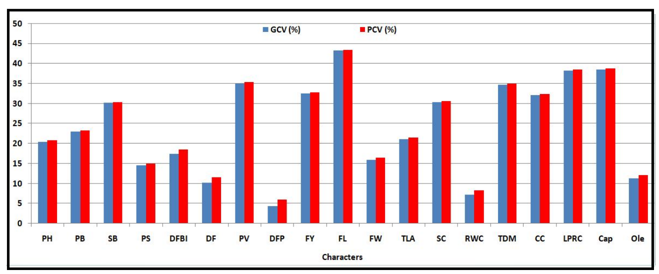

Fig. 1: Genotypic and Phenotypic coefficients of variation for different quantitative and qualitative characters in chilli grown under shade house condition at high temperature. [**PH**: Plant height (cm); **PB**: Number of primary branches; **SB**: Number of secondary branches; **PS**: Plant spread (cm); **DFBI**: Days to first flower bud initiation; **DF**: Days to 50 per cent flowering ;**PV**: Pollen viability; **DFP**: Days to first fruit picking; **FY**: Average dry fruit yield/plant (g); **FL**: Fruit length (cm); **FW**: Fruit weight (g); **TLA**: Total leaf area (dm^2/plant); **SC**: Stomatal conductance (m mol/m^2s); **RWC**: Relative water content (%); **TDM**: Total dry matter (g); **CC**: Total chlorophyll content (mg/g fr.wgt); **$LP_R C$**: Leaf proline content (µmol/g tissue); **Cap**: Capsaicin content (%); **Ole**: Oleoresin content (%)]

Table 2: Effect of temperature stress on mean performance of different traits of chilli.

Sl.No.	Genotypes	PH	PB	SB	PS	DFBI	DF	PV	DFP	FY	FL
1	UARChH-42-F_3-1	22.00	2.05	2.5	15.58	19.50	51.50	24.17	108	68	3.60
2	HYIB-13-1	22.25	2.65	3.5	18.81	36.00	56.50	16.81	105	64	3.49
3	Raichur Bullet-ML	33.75	4.86	6.62	24.50	34.00	56.50	35.08	100	115	5.70
4	Rajput yellow	27.00	2.20	3.00	20.25	44.00	72.50	28.00	104	74	3.60
5	Byadgi dabbi	28.25	2.60	3.40	23.98	33.50	53.00	10.30	104	46	3.52
6	Sitara	25.00	2.50	3.00	16.44	39.00	58.50	31.54	101	74	5.50
7	UARChH-42	31.44	2.88	3.00	24.96	35.50	55.00	32.18	99	76	5.60
8	G-4-L	32.75	3.10	3.25	19.50	40.50	70.50	16.86	98	60	4.75
9	HYIB-13-4	32.00	2.95	4.25	19.81	39.00	58.50	31.61	97	72	5.10
10	Raichur Bullet	40.50	3.20	4.33	23.12	41.00	57.00	30.49	121	116	0.85
11	BVC-42	31.45	3.16	5.00	19.81	39.50	57.50	29.66	94	68	5.25
12	HYIB-13-2-U	43.45	4.76	5.90	28.00	37.00	56.50	42.45	105	128	8.12
13	Raichur-L	32.35	3.13	4.00	25.29	39.00	58.50	28.34	102	69	2.50
14	HYIB-13-2	34.00	3.38	4.62	20.56	20.00	45.00	34.80	98	108	3.82
15	JNB-1	27.00	3.71	4.79	26.51	34.00	55.00	39.64	98	124	5.65
16	HYIB-13-3	36.25	3.43	4.25	26.34	39.00	56.00	34.84	100	114	5.80
17	UARChH-42-F_3-2	33.75	3.64	3.80	24.69	36.00	57.50	36.54	101	116	5.90
18	Raichur Bullet-1	48.5	3.21	3.00	26.50	37.50	55.50	38.76	104	119	0.94
19	UARChH-43	32.57	3.40	4.50	19.35	35.50	64.00	33.14	99	114	8.55
20	RAWE-UP	40.75	2.50	2.75	21.24	34.00	58.00	7.980	108	46	2.50
21	H-short	26.56	2.33	3.00	23.15	30.50	71.00	18.33	103	51	3.60
22	ACB-1	36.75	4.56	5.85	22.31	38.50	52.50	33.08	103	86	3.46
23	Guntur	23.75	3.47	4.87	20.88	35.50	63.50	32.68	106	78	3.80
24	Byadgi dabbi – S	31.75	3.10	4.5	21.40	22.50	60.00	8.710	98	44	2.90
	C.D. (5%)	2.75	0.26	0.28	1.746	4.50	6.81	3.11	8.76	7.25	0.41
	SE(m)	0.934	0.09	0.10	0.593	1.52	2.31	1.05	2.99	2.48	0.14
	SE(d)	1.321	0.13	0.14	0.839	2.16	3.72	1.49	4.23	3.50	0.19
	C.V.	4.1	3.93	3.46	3.77	6.17	5.61	5.31	4.14	4.17	4.53

Continue ...2

Sl.No.	Genotypes	FW	TLA	SC	RWC	TDM	CC	LP_RC	Cap	Ole
1	UARChH-42-F_3-1	1.06	18.78	38.35	76.93	8.60	0.80	4.67	0.17	10.42
2	HYIB-13-1	0.89	14.21	36.59	58.12	15.70	0.72	5.44	0.09	10.39
3	Raichur Bullet-ML	1.29	30.14	83.20	81.63	12.80	1.06	5.84	0.37	12.39
4	Rajput yellow	1.05	18.45	57.40	85.49	5.60	0.93	7.27	0.21	10.10
5	Byadgi dabbi	0.89	19.89	45.46	87.77	18.10	0.84	7.37	0.18	10.24
6	Sitara	1.13	21.31	50.25	84.43	14.70	0.92	7.40	0.28	11.57
7	UARChH-42	1.32	28.62	69.50	85.11	14.40	0.89	8.04	0.23	11.70
8	G-4-L	1.03	19.86	64.85	85.75	10.80	0.46	8.20	0.12	8.64
9	HYIB-13-4	1.18	24.14	63.45	82.76	14.70	1.07	9.00	0.12	11.44
10	Raichur Bullet	1.25	23.09	55.50	84.98	10.80	1.12	9.60	0.32	11.30
11	BVC-42	1.11	29.98	36.40	77.49	17.20	0.72	9.86	0.25	11.14
12	HYIB-13-2-U	1.64	32.54	99.76	80.98	19.80	1.85	10.31	0.44	12.73
13	Raichur-L	1.24	25.45	75.16	80.35	25.80	0.88	9.98	0.23	10.45
14	HYIB-13-2	1.28	31.32	65.56	83.33	17.20	0.89	8.88	0.18	12.30
15	JNB-1	1.44	32.42	94.56	75.69	19.10	1.05	7.40	0.35	12.72
16	HYIB-13-3	1.31	31.68	76.85	69.68	17.70	1.27	1.53	0.32	12.33
17	UARChH-42-F_3-2	1.39	31.49	57.03	84.16	18.60	1.06	2.70	0.19	12.66
18	Raichur Bullet-1	1.26	32.10	91.73	80.50	29.30	1.26	9.06	0.33	12.68
19	UARChH-43	1.48	30.14	76.06	76.43	14.50	0.74	9.34	0.27	12.10

Continue ...2

20	RAWE-UP	1.05	29.01	60.56	82.47	14.40	0.41	1.33	0.16	9.64
21	H-short	0.89	20.40	38.13	81.26	4.70	0.45	3.01	0.11	9.37
22	ACB-1	1.16	31.90	88.70	79.28	18.10	1.10	9.18	0.18	12.00
23	Guntur	1.13	30.34	84.16	84.24	16.40	1.12	8.78	0.30	11.74
24	Byadgi dabbi – S	1.01	30.21	41.15	84.16	16.10	0.87	7.47	0.21	8.33
	C.D. (5%)	0.11	2.23	5.88	6.77	1.38	0.084	0.61	0.01	1.00
	SE(m)	0.04	0.76	2.01	2.31	0.47	0.03	0.21	0.006	0.34
	SE(d)	0.05	1.08	2.84	3.27	0.66	0.04	0.29	0.009	0.48
	C.V.	4.28	4.05	4.40	4.06	4.27	4.28	4.22	4.24	4.34

PH: Plant height (cm); **PB**: Number of primary branches; **SB**: Number of secondary branches; **PS**: Plant spread (cm); **DFBI**: Days to first flower bud initiation; **DF**: Days to 50 per cent flowering ;**PV**: Pollen viability; **DFP**: Days to first fruit picking; **FY**: Average dry fruit yield/plant (g); **FL**: Fruit length (cm); **FW**: Fruit weight (g); **TLA**: Total leaf area (dm^2/plant); **SC**: Stomatal conductance (m mol/m^2s); **RWC**: Relative water content (%); **TDM**: Total dry matter (g); **CC**: Total chlorophyll content (mg/g fr.wgt); **LP_RC**: Leaf proline content (μmol/g tissue); **Cap**: Capsaicin content (%); **Ole**: Oleoresin content (%)

gravimetric method described by Weatherly (1950). Total dry matter was estimated by oven dry method where different plant parts like leaf, stem and reproductive parts were separated. The sample was first air dried and then oven dried to a constant weight at 70°C in hot air and their dry weight was expressed in gram after harvest. Stomatal conductance was measured by using leaf porometer instrument. Total chlorophyll content was estimated following the standard procedure developed by Hiscox and Israelstam (1979). Leaf proline content was determined by the method adopted by Bates *et al.*, (1973). Capsaicin content was estimated by the procedure proposed by Palacio (1977) and Oleoresin content was estimated by following gravity method (Ranganna, 1977).

The genotypic and phenotypic coefficients of variation were estimated by the formulae given by Burton and Devane (1953), Heritability in broad sense was estimated by the formula given by Hanson *et al.*, (1953) and Genetic advance as per cent of mean for each character was worked out by adopting the formula given by Johanson *et al.,* (1955).

Results and Discussion

The characters like plant height, plant spread, number of primary branches, number of secondary branches, pollen viability, fruit length, fruit weight, total leaf area, relative water content, total dry matter and average fruit yield per plant were affected by high temperature (Table 2). Similar findings were obtained by Farooq *et al.*, (2010) and Saha *et al.*, (2010) for plant height which depicts that higher temperature causes the loss of cell turgor and subsequently hampers cell elongation and plant growth leading to reduced plant heights. Farooq *et al.*, (2010) also reported similarly conclusive results in chilli under heat stress. They claimed that changes in climatic conditions, more so the temperature; bring about significant variation in the vegetative characteristics of chilli like plant height, primary branches, secondary branches, plant spread. Genotypes like Raichur Bullet-1 and HYIB-13-2-U recorded highest plant height which differed significantly. Raichur Bullet-ML, HYIB-13-2-U followed by JNB-1 recorded maximum number of primary branches and secondary branches which differed significantly. First flower bud development from the date of transplanting was recorded earliest in UARChH-42-F_3-1 followed by HYIB-13-2 and Byadgi dabbi – S, similar results were found by Ukkund *et al.*, (2007) and Amit *et al.*, (2014) who claims that the difference in flowering period during summer is due to variation in effective accumulative temperature during summer which will be in increasing order or vice-versa. Earliest 50 per cent flowering among the genotypes was recorded in HYIB-13-2 and it was followed by UARChH-42-F_3-1. The difference in days to 50 per cent flowering was due to genetic variation of genotype and lesser effects of soil type and environment. The outcomes are in consistent with the findings of Vijaya *et al.*, (2014) and Yatagiri *et al.*, (2017).

Highest pollen viability was observed in HYIB-13-2-U followed by JNB-1and Raichur Bullet- 1 which differed significantly. Similar results were obtained by Usman *et al.*, (1999), Aloni *et al.*, (2001) and Erickson and Markhart (2002). Higher temperatures during flowering have been shown to affect pollen viability, pollen tube growth and fertilization in chilli. Kuo *et al.*, (1986) reported that, with rise in temperature, the amount of proline content in pollen was reduced which in-turn reduces the pollen germination. The first fruit harvest occurred substantially earlier in BVC-42 followed by HYIB-13-4 and JNB-1. The highest yield was noted in HYIB-13-2-U (128g) followed by JNB-1 (124g) and Raichur Bullet-1 (119g). The variation in chilli genotypes for fruit yield per plant was also reported by Cheema *et al.*, (2010) and Rohini and Laxmanan (2014). The length

Table 3: Analysis of variance for quantitative and qualitative traits in chilli under shade house at high temperature.

SV	df	PH	PB	SB	PS
T	23	87.74**	1.09**	0.50**	21.43**
R	1	0.66	0.01	0.01	0.18
E	23	1.75	0.02	0.01	0.70
Continue ...3					
SV	**df**	**DFBI**	**DF**	**PV**	**DFP**
T	23	78.59**	81.05**	195.32**	57.33**
R	1	0.19	0.75	0.085	38.70
E	**23**	**4.67**	**10.70**	**2.24**	**17.93**
Continue ...3					
SV	**df**	**FY**	**FL**	**FW**	**TLA**
T	23	1483.39**	7.09**	0.07**	63.52**
R	1	0.70	0.07	0.004	0.93
E	23	12.26	0.03	0.002	1.16
Continue ...3					
SV	**df**	**SC**	**RWC**	**TDM**	**CC**
T	23	773.05**	78.50**	59.20**	0.18**
R	1	3.95	15.57	0.12	0.001
E	23	8.10	10.71	0.44	0.001
Continue ...3					
SV	**df**	**LP_RC**	**Cap**	**Ole**	
T	23	14.44**	0.02**	3.44**	
R	1	0.075	0.01	0.37	
E	23	0.08	0.01	0.24	

PH: Plant height (cm); **PB**: Number of primary branches; **SB**: Number of secondary branches; **PS**: Plant spread (cm); **DFBI**: Days to first flower bud initiation; **DF**: Days to 50 per cent flowering ;**PV**: Pollen viability; **DFP**: Days to first fruit picking; **FY**: Average dry fruit yield/plant (g); **FL**: Fruit length (cm); **FW**: Fruit weight (g); **TLA**: Total leaf area (dm^2/plant); **SC**: Stomatal conductance (m mol/m^2s); **RWC**: Relative water content (%); **TDM**: Total dry matter (g); **CC**: Total chlorophyll content (mg/g fr.wgt); **LP_RC**: Leaf proline content (µmol/g tissue); **Cap**: Capsaicin content (%); **Ole**: Oleoresin content (%)

of the fruits differed significantly between the chilli genotypes. Increase in temperature reduced the average length of fruits in all the genotypes. Significantly longest fruits were recorded in UARChH-43 (8.55 cm) followed by HYIB-13-2-U (8.12 cm) and UARChH-42-F_3-2 (5.90 cm). Similar findings were reported by researchers Hawthorn and Pollard (1954) who noticed that chilli fruit length was negatively affected at temperatures of 37.8 °C or higher. Average red ripe fruit weight per plant was found to be maximum in the HYIB-13-2-U (1.64g) followed by UARChH-43 (1.48g) and JNB-1 (1.44g) which differed significantly among each other. Total leaf area was found to be significantly highest in HYIB-13-2-U (32.54 dm^2) followed by JNB-1 (32.42 dm^2) and HYIB-13-3 (31.68 dm^2). A reduction in leaf area was observed in plants grown under shade house at high temperatures, owing primarily to smaller and fewer leaves per plant because higher temperature causes the loss of cell turgor and subsequently hampers cell elongation (Weston, 1988). The chilli genotypes under the evaluation showed significant variation in relative water content. It was noticed to be maximum in Byadgi dabbi followed by G-4-L and Rajput yellow. The total chlorophyll content was significantly high in HYIB-13-2-U followed by HYIB-13-3 and Raichur Bullet-1. These findings clearly show that high temperatures reduced the total chlorophyll content of chilli leaves. These findings were in congruent with the results of Reda and Mandoura, (2011) who reported that chlorophyll biosynthesis was significantly reduced when plants were exposed to high temperature stress. Raichur Bullet-1 followed by Raichur-L and HYIB-13-2-U showed maximum dry matter accumulation which differed significantly among the genotypes. Higher level of stomatal conductance and leaf proline content were noticed. Stomatal conductance was significantly high in HYIB-13-2-U followed by JNB-1 and Raichur Bullet-1. Under heat stress conditions, plants close their stomata to avoid transpiration loss, but it leads to reduced stomatal conductance resulting in lower internal CO_2 concentration, ribulose-1, 5- bisphosphate carboxylase/oxygenase enzyme activity, ATP synthesis which collectively decreases net photosynthetic rate (Camposa *et al.*, 2014) observed that stomatal closure

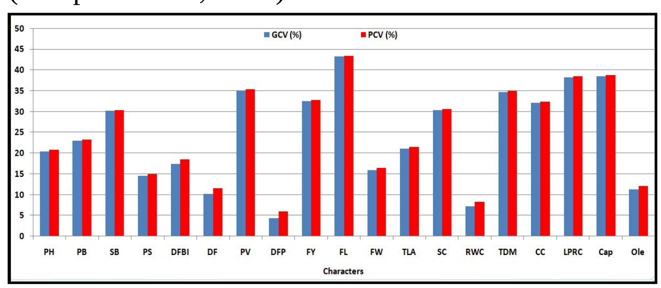

Fig. 2: Broad sense heritability and genetic advance as per cent mean for different quantitative and qualitative characters in chilli grown under shade house condition at high temperature. [**PH**: Plant height (cm); **PB**: Number of primary branches; **SB**: Number of secondary branches; **PS**: Plant spread (cm); **DFBI**: Days to first flower bud initiation; **DF**: Days to 50 per cent flowering ;**PV**: Pollen viability; **DFP**: Days to first fruit picking; **FY**: Average dry fruit yield/plant (g); **FL**: Fruit length (cm); **FW**: Fruit weight (g); **TLA**: Total leaf area (dm^2/plant); **SC**: Stomatal conductance (m mol/m^2s); **RWC**: Relative water content (%); **TDM**: Total dry matter (g); **CC**: Total chlorophyll content (mg/g fr.wgt); **LP_RC**: Leaf proline content (µmol/g tissue); **Cap**: Capsaicin content (%); **Ole**: Oleoresin content (%)]

Table 4. Genetic parameters for quantitative and qualitative characters in chilli grown under shade house condition.

Particulars	MEAN	MIN	MAX	GCV (%)	PCV (%)	h^2 (%)	GA (5%)	GAM (5%)
PH	32.24	22.00	48.5	20.35	20.75	96.10	13.24	41.06
PB	3.20	2.05	4.86	22.94	23.27	97.15	1.49	46.58
SB	3.98	2.00	6.62	30.10	30.30	98.70	2.45	61.60
PS	22.21	15.58	28.00	14.50	14.98	93.66	6.42	28.90
DFBI	35.02	19.50	44.00	17.36	18.42	88.79	11.80	33.70
DF	58.38	45.00	72.50	10.16	11.60	76.66	10.70	18.33
PV	28.17	7.97	42.45	34.88	35.29	97.73	20.01	71.04
DFP	102.33	94.00	121.00	4.34	5.99	72.38	6.62	6.47
FY	83.92	44.00	128	32.43	32.70	98.40	55.61	66.27
FL	4.35	0.85	8.55	43.14	43.37	98.71	3.85	88.38
FW	1.19	0.89	1.64	15.93	16.49	93.30	0.37	31.70
TLA	26.56	14.21	32.54	21.02	21.41	96.42	11.30	42.53
SC	64.59	36.40	99.76	30.29	30.60	97.93	39.89	61.75
RWC	80.54	58.12	87.77	7.23	8.29	75.99	10.46	12.98
TDM	15.63	4.70	29.30	34.69	34.95	98.50	11.08	70.93
CC	0.94	0.42	1.86	32.09	32.38	98.19	0.61	65.64
LP_RC	7.02	1.34	10.32	38.17	38.41	98.79	5.49	78.17
Cap	0.23	0.09	0.44	38.49	38.72	98.80	0.18	78.81
Ole	11.18	8.34	12.73	11.31	12.12	87.17	2.43	21.76

PH: Plant height (cm); **PB**: Number of primary branches; **SB**: Number of secondary branches; **PS**: Plant spread (cm); **DFBI**: Days to first flower bud initiation; **DF**: Days to 50 per cent flowering ;**PV**: Pollen viability; **DFP**: Days to first fruit picking; **FY**: Average dry fruit yield/plant (g); **FL**: Fruit length (cm); **FW**: Fruit weight (g); **TLA**: Total leaf area (dm^2/plant); **SC**: Stomatal conductance (m mol/m^2s); **RWC**: Relative water content (%); **TDM**: Total dry matter (g); **CC**: Total chlorophyll content (mg/g fr.wgt); **LP_RC**: Leaf proline content (µmol/g tissue); **Cap**: Capsaicin content (%); **Ole**: Oleoresin content (%)

was a major limiting factor of photosynthesis in chili plants. HYIB-13-2-U had the highest leaf proline content followed by Raichur-L and BVC-42. Similar results were obtained by Navita *et al.*, (2016).

While, quality traits like oleoresin and capsaicin content showed variable response under heat stress condition. HYIB-13-2-U followed by Raichur Bullet- ML and JNB-1 recorded highest capsaicin content and oleoresin content. Analysis of variance (ANOVA) showed highly significant mean sum of square values as a result of genotypes for all the traits, which exhibits that the genotypes differed with each other for the character studies (Table 3). Range, mean, coefficients of genotypic and phenotypic variation, heritability estimates in broad sense, genetic advance and per cent mean genetic advance for all these traits are presented in Table 4.

Genetic variability studies revealed that high genotypic co-efficient of variability and phenotypic co-efficient of variability was noticed for plant height, number of primary branches, number of secondary branches, pollen viability, average red ripe fruit yield, fruit length, total leaf area, stomatal conductance, total dry matter, total chlorophyll content, leaf proline and capsaicin content. High GCV and PCV indicate the existence of greater variability for these characters in the experimental material, which gives ample scope for improvement of these traits by simple selection. Moderate GCV and PCV was observed by plant spread, days to first flower bud initiation, days to 50 per cent flowering, fruit weight, oleoresin content. Low GCV and PCV was noticed for

Table 5: Monthly meteorological data observed during the reproductive stage of chilli grown under shade house condition in the year 2022.

Sl. No.	Month	Shade house condition						
		Temperature (°C)		Mean	RH-I	RH-II	Mean RH	SS
		Max.	Min.	(°C)	(%)	(%)	(%)	(hrs)
1	March	37.1	21.0	29.1	61.0	20.4	40.7	7.7
2	April	38.9	23.5	31.0	63.2	32.5	47.9	6.4
3	May	38.0	23.6	30.8	69.0	33.6	51.3	5.0
4	June	35.2	21.4	28.3	77.5	39.2	58.4	4.0
	Mean	37.3	22.4	29.9	67.7	31.4	49.6	5.8

days to first fruit picking and relative water content which suggests low variability for such characters among genotypes. Almost for all the characters there was a narrow difference between PCV and GCV which indicates the lesser influence of environmental effect on these traits.

High heritability coupled with high genetic advance as percent of mean was noticed for., plant height, plant spread, number of primary branches, number of secondary branches, days to first flower bud initiation, pollen viability, average fruit yield per plant, fruit length, fruit weight, total leaf area, stomatal conductance, total dry matter, total chlorophyll content, leaf proline content, capsaicin content, and oleoresin content indicating presence of additive gene action, hence, the improvement through selection for these characters will be more fruitful. Relative water content and days to 50 per cent flowering showed low and moderate GCV and PCV coupled with high heritability and moderate genetic advance as a per cent mean which indicates that both additive and non-additive gene action prevails and hence, improvement of these traits through selection will be less effective.

Discussion

The high temperature stress critically affected both vegetative and reproductive traits of chilli genotypes under shade house conditions, manifesting as reduced plant height, limited branching, and diminished fruit length and weight. These impacts align with previous research indicating that heat stresses impair cell turgor, directly hampering elongation and growth, which was evident in the significant decline in plant stature and branching across most genotypes. Notably, genotypes such as HYIB-13-2-U and Raichur Bullet-1 performed superiorly, consistently showing higher plant height and better branching, marking them as more heat-tolerant varieties.

Additionally, high temperature during flowering adversely influenced pollen viability—crucial for fruit set—yet HYIB-13-2-U and JNB-1 displayed greater resilience in this aspect, suggesting their suitability for cultivation in warmer seasons. Flowering and subsequent fruit picking were delayed in some entries, while a few genotypes exhibited earlier reproductive phases, which is interpreted as potential thermotolerance and adaptability. Fruit characteristics, especially length and fresh yield, universally declined with temperature spikes, although UARChH-43 and HYIB-13-2-U managed to maintain relatively larger fruit length and yield, reflecting their robust physiological response.

On the physiological front, total leaf area and chlorophyll content were generally lower under heat stress, but genotypes like HYIB-13-2-U and JNB-1 retained higher values, possibly conferring better photosynthetic capacity and thus yield sustainability. Relative water content remained highest in Byadgi dabbi and G-4-L, indicating effective internal water conservation, though not always translating into high yield, suggesting other underlying stress response strategies. Elevated stomatal conductance and leaf proline content in certain genotypes pointed towards adaptive mechanisms to mitigate heat-induced damage, helping maintain cellular function and growth even in stressful conditions.

Quality traits, such as oleoresin and capsaicin contents, exhibited variable responses to heat, with heat-tolerant genotypes generally retaining or enhancing these biochemical attributes, further supporting their use in breeding programs. The genetic variability analysis confirmed high genotypic and phenotypic coefficients of variation and heritability for most yield and physiological traits, indicating strong opportunities for selection and genetic improvement. However, low variability and genetic advance in relative water content and certain flowering traits suggested limited scope for progress on those fronts through conventional selection. Overall, the findings emphasize that selecting for traits such as pollen viability, fruit yield, chlorophyll content, and physiological robustness can effectively enhance heat tolerance in chilli breeding programs.

Conclusion

The present study was conducted to identify the high temperatures tolerant genotypes of chilli under shade house condition. Among 24 genotypes HYIB-13-2-U followed by JNB-1, Raichur Bullet-1, UARChH-42-F_3-2, Raichur Bullet, Raichur Bullet- ML, HYIB-13-3 and UARChH-43 were found to be more temperature tolerant compared to other genotypes as they showed maximum yield coupled with higher per se performance for the traits like plant height, plant spread, number of primary and secondary branches, pollen viability, fruit length, fruit weight and chlorophyll content. So these genotypes can be used for further exploitation in the tolerance breeding programmes.

References

Aloni, B., Peet M.M, Pharr M. and Karni L. (2001). The effect of high temperature and high atmospheric CO_2 on carbohydrate changes in bell pepper (*Capsicum annum* L.) pollen in relation to its germination. *Plant Physiol.*, **112**, 505–512.

Amit, K., Ahad I. and Kumar V. (2014). Genetic variability and correlation studies for growth and yield characters in chilli (*Capsicum annuum* L.) *J. Spices. Aromatic crops*., **23(2)**, 170-177.

Bates, L.S., Waldeen R.P. and Teare I.D. (1973). Rapid determination of free proline in water stresses studies. *Plant Soil*., **39**, 205-207.

Burton, G.W. and De Vane E.M. (1953). Estimating heritability in tall fescue *(Festuca circunclinaceae)* from replicated clonal material. *Agron. J*., **45**, 478-481.

Camposa, H., Trejob C., Valdiviab C.B.P., Navab R.G., Conde-Martínezb F.V. and Cruz-Ortegac M.R. (2014). Morpho-physiological changes occurring in chilli genotypes 49 Stomatal and non-stomatal limitations of bell pepper (*Capsicum annuum* L.) plants under water stress and re watering: Delayed restoration of photosynthesis during recovery. *Environ. Exp. Bot*., **98**, 56-64.

Cheema, D.S., Jindal S.K. and Dhaliwal M.S. (2010). Evaluation of chilli hybrids developed by using genetic male sterility. *Haryana J. Horti. Sci*., **39(3,4)**, 321-325.

Demers, D.A., Yelle S. and Gosselin A. (1994). Effects of continuous lighting on enzyme activities of leaf carbon metabolism of tomato and pepper plants. *Hort. Sci*., **30(4)**, 250.

Erickson, A.N. and Markhart A.H. (2002). Flower developmental stage and organ sensitivity of bell pepper (*Capsicum annuum* L.) to elevated temperature. *Plant Cell Environ*., **25**, 123-130.

Farooq, M., Kobayashi N., Ito O., Wahid A. and Serraj R. (2010). Broader leaves result in better performance of indica rice under drought stress. *J. Plant Physiol*., **167(13)**, 1066-1075.

Hanson, G.H., Robinson H.F. and Comstack R.E. (1953). Biometrical studies of yield in segregating populations of Korian Lespedeza. *Agron. J.*, **48**, 267-282.

Hawthorn, L.R. and Pollard H. (1954). Vegetable and flower seed producton. *Blakiston Company Inc*., *New York*., **4**, 125.

Hiscox, J.D. and Israelstam G.F. (1979). A method for the extraction of chlorophyll from leaf tissue without maceration. *Canad. J. Bot*., **57(12)**, 1332-1334.

Jensen, W.A. (1962). Botanical histochemistry, freeman & Co. Sanfransisco.

Johanson, R.E., Robinson H.W. and Comstock H.F. (1955). Estimates of genetic and environmental variability in soybean. *Agron. J*., **47**, 314-318.

Kuo, E.G., Chen H.M. and Ma L.H. (1986). Effect of high temperature on proline content in tomato floral buds and leaves. *J. Amer. Soc. Hort. Sci*., **111**, 734-750.

Murage, E.N., Sato Y. and Masuda M. (1994). Relationship between dark period and leaf chlorosis and mineral status in solanaceae plants under artificial illumination. *J. Jpn. Soc. Hort. Sci*., **64**, 26-27.

Navita, G., Jaspreet K., Jindal S.K., Dhaliwal M.S. and Kanchan P. (2016). Physiological and biochemical response to higher temperature stress in hot pepper (*Capsicum annuum* L.). *J. App. Natural Sci*., **8(3)**, 1133- 1137.

Palacio, J.J. (1977). Spectro-photometric determination of capsaicin. *J. Assoc. Off. Anal. Chem*., **60(4)**, 970-972.

Ranganna, S. (1977). Manual analysis of fruit and vegetable products, *Tata McGraw Hill Publishing Co. Ltd*., New Delhi, India., 81-85.

Reda, F. and Mandoura H.M.H. (2011). Response of enzymes activities, photosynthetic pigments, proline to low or high temperature stressed wheat plant (*Triticum aestivum* L.) in the presence or absence of exogenous proline or cysteine. *Int. J. Acad. Res*., **3**, 108-115.

Rohini, N. and Lakshmanan V. (2014). Evaluation of chilli hybrids for yield and related traits. *Biosci Trends*., **7(22)**, 3635-3638.

Saha, S.R., Hossain M.M., Rahman M.M., Kuo C.G. and Abdullah S. (September 2010). Effect of high temperature stress on the performance of twelve sweet pepper genotypes ISSN 0258-7122. *Bangladesh J. Agril. Res*., **35(3)**, 525-534.

Ukkund, K.M., Madalageri M.B., Pati M.P., Mulage R. and Kotikal Y.K. (2007). Variability studies in green Chilli (*Capsicum annuum* L.) *Karnataka J Agri. Sci*., **20(1)**, 102-104.

Usman, I.S, Mamat A.S, Mohammed H.S.Z.S, Aishah H.S. and Ahuar A.R. (1999). The non-impairment of pollination and fertilization in the abscission of chilli (*Capsicum annum* L. var. Kulai) flowers under high temperature and humid conditions. *Sci. Hort*., **79**, 1-11.

Vijaya, H.M., Gowda A.P. and Mallikarjun Nehru S.D. (2014). Genetic variability, correlation coefficient and path analysis. *Res. Environ. Life Sci*., **7(3)**, 175-178.

Vivekanandan, A.S., Gunasena H.P.M. and Sivananyagam T. (1972). Statistical evaluation of accuracy of three techniques used in estimation of leaf area of crop plants. *Indian J. Agric. Sci*., **42**, 857- 860.

Weatherly, P. E. (1950). Studies in the water relations of cotton. 1. The field measurement of water deficits in leaves. *New Phytol*., **49**, 81-97.

Weston, L.A. (1988). Effect of flat cell size, transplant age, and production site on growth and yield of pepper transplants, *Hort. Sci*., **23**, 709-711.

Yatagiri, N., Sanap P.B. and Telugu R.K. (2017). Growth, flowering behavior and physical frui parameters of chilli (*Capsicum annuum* L.) genotypes in coastal Maharashtra. *Int. J. Curr. Microbiol. App. Sci*., **6(7)**, 2230-2237.