



Identification of morphological traits associated with chilli thrips (*Scirtothrips dorsalis*) resistance in bird's eye chilli (*Capsicum frutescens*)

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ABSTRACT

Chilli thrips [*Scirtothrips dorsalis* (Hood)], is a major constraint to bird's eye chilli (*Capsicum frutescens* L.) production, causing severe leaf curl and yield losses under tropical conditions. The present study was carried out to identify leaf morphological traits associated with resistance to chilli thrips in bird's eye chilli under field conditions during winter (*rabi*) season of 2024–25 and summer 2025 at College of Agriculture (University of Agricultural Sciences, Bengaluru, Karnataka), Karekere, Hassan, Karnataka. Twenty-one entries, comprising 18 indigenous landraces and three check varieties, were evaluated, using a randomised complete block design (RCBD) with two replications under natural infestation. Thrips population density and leaf curl index were recorded at pre-flowering, flowering, and post-flowering stages. Significant variability in thrips incidence and damage was observed among the landraces across both seasons. Landraces UASBCF-27, UASBCF-29, and UASBCF-30 consistently exhibited moderate resistance, recording lower thrips populations and reduced leaf curl symptoms, whereas UASBCF-6 and susceptible checks showed maximum infestation. Comparative morphological analysis revealed that resistant landraces possessed significantly higher trichome density, longer trichomes, and greater epicuticular wax deposition than susceptible entries. Thrips incidence exhibited strong negative associations with these traits, suggesting their role in antixenosis-mediated resistance. The study highlights the significance of leaf morphological traits in imparting resistance to chilli thrips and identifies promising donor landraces for breeding thrips-resistant cultivars toward sustainable chilli production.

Keywords: Antixenosis resistance, Epicuticular wax, Host plant resistance, Trichome density

Chilli (*Capsicum* spp.) is an economically important vegetable and spice crop cultivated worldwide for its culinary, nutritional, and pharmaceutical significance (Hernández-Pérez *et al.* 2020). India is the largest producer and exporter of chilli, where the crop contributes substantially to agricultural income and the spice industry (Misal *et al.* 2022). Chilli fruits are valued for their pungency, flavour, and rich composition of bioactive compounds, including capsaicinoids, flavonoids, polyphenols, carotenoids, vitamins A, C, E, and essential minerals, which impart significant antioxidant, medicinal, and health-promoting properties (Hazra *et al.* 2026). Among the domesticated species, bird's eye chilli (*Capsicum frutescens* L.) is particularly known for its intense pungency, distinct aroma, medicinal importance,

and adaptability to diverse agro-climatic conditions (Alonso Villegas *et al.* 2023).

Despite its economic importance, chilli production is severely affected by several insect pests, among which chilli thrips [*Scirtothrips dorsalis* (Hood) (Thysanoptera: Thripidae)], is one of the most destructive sucking pests in India (Reddy and Puttaswamy 1984). Both nymphs and adults feed on tender plant tissues by rasping and sucking cell sap, causing leaf curling, crinkling, bronzing, flower drop, and malformed fruits, leading to severe reductions in yield and market quality. Under heavy infestation, yield losses may range from 30–70% (Sridhar *et al.* 2021, Sadafale *et al.* 2025a, b). Management of *S. dorsalis* mainly depends on repeated insecticide applications; however, its cryptic feeding behaviour, rapid multiplication, and wide host range often reduce control efficiency. Indiscriminate pesticide use has further resulted in insecticide resistance, pest resurgence, environmental contamination, and adverse effects on natural enemies (Sadafale *et al.* 2025a).

Host plant resistance (HPR) is considered an effective and eco-friendly approach for sustainable management of chilli thrips. Resistance mechanisms in chilli involve

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morphological and biochemical traits that influence insect colonisation, feeding, and survival. Morphological traits such as trichome density, trichome length, leaf thickness, and epicuticular wax deposition act as important antixenotic barriers against thrips infestation, while biochemical constituents further modulate pest behaviour and development (Panda and Khush 1995, Chakraborty and Sarkar 2011, Sadafale *et al.* 2025b, c, d). Although substantial variability exists among chilli landraces for resistance to *S. dorsalis*, information on the morphological basis of resistance in bird's eye chilli remains limited. Therefore, the present investigation was undertaken to identify key morphological traits associated with resistance to chilli thrips in contrasting bird's eye chilli landraces for their utilisation in resistance breeding programmes.

MATERIALS AND METHODS

Experimental site and plant material: The study was carried out during winter (*rabi*) season of 2024–25 and summer 2025 at College of Agriculture (University of Agricultural Sciences, Bengaluru, Karnataka), Karekere, Hassan (12.95°N and 76.10°E), Karnataka. Experimental material comprised 18 indigenous bird's eye chilli landraces collected from Karnataka and Kerala, along with three check varieties, namely Byadagi Kaddi, Byadagi Dabbi (*C. annuum*), and Vellayani Samrudhi (*C. frutescens*) (Supplementary Table 1).

Experimental design and field screening: The experiment was laid out in a randomised complete block design (RCBD) with two replications under natural infestation. Thirty to thirty-five-days-old seedlings were transplanted at a spacing of 60 cm × 45 cm and maintained following recommended agronomic practices, excluding plant protection measures.

Thrips resistance was evaluated based on thrips population density and leaf curl severity. Observations were recorded from five randomly selected plants per entry at pre-flowering, flowering, and post-flowering stages. Thrips population (nymphs and adults) was estimated by tapping terminal shoots over a white sheet and expressed as the mean number of thrips per three young shoots per plant (Pavani *et al.* 2024). Leaf curl severity was assessed using the 0–4 visual rating scale of Niles (1980) (Supplementary Table 2, Supplementary Fig. 1), and the leaf curl index (LCI) was calculated as:

$$\text{LCI (\%)} = \frac{[\Sigma (\text{Rating} \times \text{Number of leaves in that rating}) / (\text{Total number of leaves} \times \text{Maximum rating})] \times 100}$$

Based on mean LCI values, entries were categorised into resistance classes following Niles (1980).

Selection of contrasting landraces: Based on pooled screening results, 12 contrasting landraces representing different resistance categories were selected for detailed morphological analysis using mean thrips population and LCI recorded at the flowering stage.

Morphological traits: Trichome density and trichome length were measured on adaxial and abaxial leaf surfaces using stereo-binocular and trinocular microscopes,

respectively. Epicuticular wax content was estimated following the method of Ebercon *et al.* (1977) and expressed as:

$$\text{Wax load } (\mu\text{g}/\text{dm}^2) = \frac{\text{Total wax extracted } (\mu\text{g})}{\text{Leaf surface area } (\text{dm}^2)}$$

Where 5.54 dm² represented the total leaf surface area used for wax extraction.

Statistical analysis: Thrips population data were transformed using $\sqrt{x + 0.5}$, while LCI values were angular transformed before analysis. Data were subjected to analysis of variance (ANOVA), and treatment means were separated using Tukey's HSD test (Tukey 1965). Pearson's correlation coefficient (*r*) was computed to determine relationships between thrips incidence and morphological traits.

RESULTS AND DISCUSSION

Screening of chilli landraces against *S. dorsalis* during *rabi* 2024–25 and summer 2025: Eighteen bird's eye chilli landraces and three check varieties were screened against chilli thrips under field conditions during *rabi* 2024–25 and summer 2025. Thrips incidence was recorded at pre-flowering, flowering, and post-flowering stages (Table 1 and 2). Significant variation in thrips infestation was observed among the evaluated entries, indicating the presence of genetic variability for resistance. During *rabi* 2024–25, the mean thrips population ranged from 7.07–16.08 thrips per three young shoots. UASBCF-29 recorded the lowest mean population (7.07 thrips), followed by UASBCF-30 (7.20 thrips) and UASBCF-27 (7.73 thrips), indicating a resistant reaction. In contrast, UASBCF-6 (15.27 thrips) was statistically comparable with the susceptible checks Byadagi Dabbi (15.70 thrips) and Byadagi Kaddi (16.08 thrips), which consistently supported higher infestation levels. Across landraces, thrips populations were generally highest during the flowering stage. A similar trend was observed during summer 2025, when overall thrips pressure was comparatively higher. Mean thrips populations ranged from 7.63–18.80 thrips per three young shoots. UASBCF-29 again recorded the lowest infestation (7.63 thrips), followed by UASBCF-30 and UASBCF-27, confirming their stable resistance across seasons. Conversely, UASBCF-6 (17.57 thrips) and the susceptible checks Byadagi Kaddi (18.13 thrips) and Byadagi Dabbi (18.80 thrips) recorded significantly higher populations, indicating pronounced susceptibility. The consistent performance of resistant and susceptible landraces across seasons suggests that the observed variation was predominantly governed by genetic factors rather than environmental influences. Similar stable resistance responses against chilli thrips have been reported by Maharijaya *et al.* (2011), Latha and Hunumanthraya (2018), Kumar *et al.* (2020) and Sadafale *et al.* (2025c, e).

Categorisation of chilli landraces based on per cent leaf curl index: The severity of thrips damage was assessed using the per cent leaf curl index (LCI), which revealed considerable variation among the evaluated landraces (Table 3). None of the entries exhibited complete resistance

Table 1 Population density of thrips on chilli landraces at different growth stages, during *rabi* 2024–25 and summer 2024–25

Landraces	Mean number of thrips @ (<i>rabi</i> 2024–25)				Mean number of thrips @ (summer 2024–25)			
	Pre flowering	Flowering	Post flowering	Mean	Pre flowering	Flowering	Post flowering	Mean
UASBCF- 3	7.40 (2.81) ^{cd}	17.10 (4.20) ^f	16.10 (4.07) ^d	13.53 (3.69) ^e	8.60 (3.02) ^{bc}	19.80 (4.51) ^c	18.70 (4.38) ^{bc}	15.70 (3.97) ^c
UASBCF-6	8.00 (2.92) ^b	21.10 (4.65) ^b	16.70 (4.15) ^c	15.27 (3.90) ^c	9.00 (3.08) ^{bc}	24.30 (4.98) ^a	19.40 (4.46) ^b	17.57 (4.17) ^b
UASBCF-10	7.50 (2.83) ^c	18.00 (4.30) ^d	16.10 (4.07) ^d	13.87 (3.73) ^d	8.20 (2.95) ^{cd}	20.10 (4.54) ^c	18.90 (4.4) ^{bc}	15.73 (3.96) ^c
UASBCF-11	7.00 (2.74) ^{ef}	17.70 (4.27) ^e	15.80 (4.04) ^d	13.50 (3.68) ^e	8.10 (2.93) ^{cde}	20.00 (4.53) ^c	17.80 (4.28) ^c	15.30 (3.91) ^c
UASBCF-13	6.50 (2.65) ^{gh}	14.60 (3.89) ^j	13.10 (3.69) ^g	11.40 (3.41) ⁱ	7.10 (2.76) ^{fgh}	16.80 (4.16) ^e	15.20 (3.96) ^{de}	13.03 (3.63) ^d
UASBCF-15	7.20 (2.77) ^{de}	16.10 (4.07) ^g	15.30 (3.97) ^e	12.87 (3.61) ^f	12.00 (2.97) ^{cd}	18.00 (4.30) ^d	17.50 (4.29) ^c	15.83 (3.85) ^c
UASBCF-16	6.80 (2.70) ^{fg}	15.70 (4.02) ^h	13.90 (3.79) ^f	12.13 (3.51) ^g	7.50 (2.83) ^{def}	17.90 (4.29) ^d	15.70 (4.02) ^d	13.70 (3.71) ^d
UASBCF-17	6.40 (2.63) ^h	12.90 (3.66) ⁿ	11.50 (3.46) ⁱ	10.27 (3.25) ^k	7.00 (2.74) ^{fgh}	14.50 (3.87) ^{ghi}	13.60 (3.75) ^{fg}	11.70 (3.45) ^e
UASBCF-18	6.10 (2.57) ⁱ	13.70 (3.77) ^k	11.90 (3.52) ^h	10.57 (3.29) ^j	6.80 (2.70) ^{fghi}	15.20 (3.96) ^{fg}	13.70 (3.77) ^{fg}	11.90 (3.48) ^e
UASBCF-22	6.00 (2.55) ⁱ	13.50 (3.74) ^l	10.70 (3.35) ^j	10.07 (3.21) ^l	6.60 (2.66) ^{ghi}	15.00 (3.94) ^{fgh}	12.90 (3.66) ^g	11.50 (3.42) ^{ef}
UASBCF-23	5.90 (2.53) ^{ij}	12.40 (3.59) ^o	9.50 (3.16) ^l	9.27 (3.09) ⁿ	6.30 (2.61) ^{hi}	13.60 (3.75) ^j	11.40 (3.45) ^{hi}	10.43 (3.27) ^g
UASBCF-24	5.70 (2.49) ^{jk}	13.10 (3.69) ^m	10.00 (3.24) ^k	9.60 (3.14) ^m	6.10 (2.57) ⁱ	14.30 (3.85) ^{hi}	11.90 (3.52) ^h	10.77 (3.31) ^{fg}
UASBCF-25	5.40 (2.43) ^l	10.10 (3.26) ^p	8.30 (2.97) ⁿ	7.93 (2.88) ^o	8.30 (2.97) ^{cd}	11.90 (3.52) ^k	10.00 (3.24) ^{jk}	10.07 (3.24) ^g
UASBCF-26	5.60 (2.47) ^{kl}	13.40 (3.73) ^l	9.70 (3.19) ^l	9.57 (3.13) ^m	6.00 (2.55) ^{ij}	14.00 (3.81) ^{ij}	10.70 (3.35) ^{ij}	10.23 (3.24) ^g
UASBCF-27	5.10 (2.37) ^m	9.20 (3.11) ^q	8.90 (3.07) ^m	7.73 (2.85) ^p	5.30 (2.41) ^{jl}	10.20 (3.27) ^l	9.80 (3.21) ^k	8.43 (2.96) ^h
UASBCF-29	4.50 (2.24) ⁿ	8.00 (2.92) ^s	7.80 (2.88) ^o	7.07 (2.68) ^r	4.80 (2.30) ^l	9.30 (3.13) ^m	8.80 (3.05) ^l	7.63 (2.83) ⁱ
UASBCF-30	4.90 (2.32) ^m	8.90 (3.07) ^r	8.70 (3.03) ^m	7.20 (2.81) ^q	5.10 (2.37) ^l	10.10 (3.26) ^l	9.00 (3.08) ^l	8.07 (2.9) ^{hi}
UASBCF-32	6.80 (2.70) ^{fg}	15.10 (3.95) ⁱ	13.90 (3.79) ^f	11.93 (3.48) ^h	7.30 (2.79) ^{efg}	17.30 (4.22) ^{de}	15.80 (4.04) ^d	13.47 (3.68) ^d
Byadagi Kaddi	9.00 (3.08) ^a	19.25 (4.44) ^c	20.00 (4.53) ^a	16.08 (4.02) ^a	10.10 (3.26) ^a	22.30 (4.77) ^b	22.00 (4.74) ^a	18.13 (4.26) ^{ab}
Byadagi Dabbi	8.30 (2.97) ^b	21.95 (4.74) ^a	17.70 (4.27) ^b	15.70 (3.99) ^b	9.40 (3.15) ^{ab}	25.10 (5.06) ^a	21.9 (4.73) ^a	18.80 (4.31) ^a
Vellayani Samrudhi	5.7 (2.49) ^{jk}	13.5 (3.74) ^l	13.00 (3.67) ^g	10.73 (3.30) ^j	6.00 (2.55) ^{ijk}	15.50 (4.00) ^f	14.40 (3.86) ^{ef}	11.97 (3.47) ^c
F test	*	*	*	*	*	*	*	*
SEM ±	(0.01)	(0.006)	(0.007)	(0.006)	(0.046)	(0.031)	(0.024)	(0.02)
CD (<i>p</i> =0.05)	(0.03)	(0.017)	(0.021)	(0.017)	(0.138)	(0.092)	(0.071)	(0.059)

@from three young shoots; *, Significant at 5% probability; Figures in the parentheses are $\sqrt{x+0.5}$ transformed values; Treatments with same alphabetical superscript within the column are statistically on par.

Table 2. LCI score for thrips infestation in chilli landraces at different stages of growth, during *rabi* 2024–25 and summer 2024–25 (based on mean per cent leaf curl index)

Landraces	Leaf curl index (per cent) at different growth stages (<i>rabi</i> 2024–25)				Leaf curl index (per cent) at different growth stages (summer 2024–25)			
	Pre flowering	Flowering	Post flowering	Mean	Pre flowering	Flowering	Post flowering	Mean
UASBCF- 3	55 (47.85) ^c	63 (52.52) ^{bc}	61 (51.34) ^b	59.67 (50.56) ^c	56 (48.43) ^c	64 (53.11) ^c	62 (51.92) ^d	60.67 (51.14) ^c
UASBCF-6	61 (51.34) ^a	68 (55.53) ^{ab}	67 (54.92) ^a	65.33 (53.91) ^a	60 (50.75) ^b	70 (56.77) ^{ab}	66 (54.31) ^b	65.33 (53.91) ^b
UASBCF-10	57 (49.01) ^b	65 (53.71) ^{ab}	63 (52.52) ^{ab}	61.67 (51.73) ^{bc}	56 (48.43) ^c	66 (54.31) ^c	64 (53.11) ^c	62.00 (51.92) ^c
UASBCF-11	50 (44.98) ^c	57 (49.01) ^d	55 (47.85) ^c	54.00 (47.28) ^d	52 (46.13) ^d	5 (49.58) ^d	54 (47.28) ^c	54.67 (47.66) ^d
UASBCF-13	45 (42.11) ^f	47 (43.26) ^e	45 (42.11) ^{efg}	45.67 (42.50) ^f	46 (42.69) ^c	48 (43.84) ^c	46 (42.69) ⁱ	46.67 (43.07) ^g
UASBCF-15	53 (46.70) ^d	58 (49.58) ^{cd}	51 (45.56) ^{cd}	54.00 (47.28) ^d	52 (46.13) ^d	60 (50.75) ^d	52 (46.13) ^f	54.67 (47.66) ^d
UASBCF-16	49 (44.41) ^e	47 (43.26) ^e	51 (45.56) ^{cd}	49.00 (44.41) ^e	50 (44.98) ^d	48 (43.84) ^c	52 (46.13) ^f	50.00 (44.98) ^e
UASBCF-17	43 (40.96) ^g	47 (43.26) ^e	48 (43.84) ^{def}	46.00 (42.69) ^{ef}	44 (41.54) ^{ef}	48 (43.84) ^c	50 (44.98) ^h	47.33 (43.45) ^{fg}
UASBCF-18	41 (39.80) ^h	44 (41.54) ^{ef}	42 (40.38) ^{gh}	42.33 (40.57) ^g	42 (40.38) ^{fg}	46 (42.69) ^{ef}	44 (41.54) ^j	44.00 (41.54) ^h
UASBCF-22	35 (36.25) ^j	42 (40.38) ^{ef}	44 (41.54) ^{fgh}	40.33 (39.41) ^{gh}	36 (36.85) ⁱ	44 (41.54) ^{fg}	46 (42.69) ⁱ	42.00 (40.38) ⁱ
UASBCF-23	36 (36.85) ^j	42 (40.38) ^{ef}	39 (38.63) ^{hi}	39.00 (38.63) ^{hi}	38 (38.04) ^{hi}	44 (41.54) ^{fg}	40 (39.22) ^j	40.67 (39.61) ⁱ
UASBCF-24	38 (38.04) ⁱ	42 (40.38) ^{ef}	42 (40.38) ^{gh}	40.67 (39.6) ^{gh}	40 (39.22) ^{gh}	42 (40.38) ^g	44 (41.54) ^j	42.00 (40.38) ⁱ
UASBCF-25	29 (32.56) ^l	36 (36.85) ^g	36 (36.85) ⁱ	33.67 (35.45) ^{jk}	30 (33.2) ^j	38 (38.04) ^h	38 (38.04) ^m	35.33 (36.45) ^k
UASBCF-26	30 (33.19) ^k	39 (38.63) ^{fg}	40 (39.22) ^{ghi}	36.33 (37.05) ^{ij}	32 (34.43) ^j	42 (40.38) ^g	42 (40.38) ^k	38.67 (38.44) ^j
UASBCF-27	22 (27.94) ⁿ	23 (28.64) ^h	22 (27.96) ^j	22.33 (28.19) ^l	24 (29.32) ^k	24 (29.32) ⁱ	22 (27.96) ^o	23.33 (28.87) ^l
UASBCF-29	17 (24.3) ^p	19 (25.82) ^h	21 (27.26) ^j	19.00 (25.83) ^m	18 (25.09) ^l	22 (27.96) ⁱ	20 (26.55) ^p	20.00 (26.55) ^m
UASBCF-30	21 (27.24) ^o	23 (28.64) ^h	24 (29.32) ^j	22.67 (28.42) ^l	22 (27.96) ^k	24 (29.32) ⁱ	24 (29.32) ⁿ	23.33 (28.87) ^l
UASBCF-32	26 (30.63) ^m	35 (36.26) ^g	35 (36.26) ⁱ	32.00 (34.44) ^k	50 (44.98) ^d	46 (42.69) ^{ef}	50 (44.98) ^h	48.67 (44.22) ^{ef}
Byadagi Kaddi	60 (50.75) ^a	69 (56.15) ^a	66 (54.31) ^{ab}	65.00 (53.71) ^a	65 (53.71) ^a	72 (58.03) ^a	66 (54.31) ^b	67.67 (55.33) ^a
Byadagi Dabbi	60 (50.75) ^a	67 (54.92) ^{ab}	66 (54.31) ^{ab}	64.33 (53.31) ^{ab}	61 (51.34) ^b	69 (56.15) ^b	67 (54.92) ^a	65.67 (54.11) ^b
Vellayani Samrudhi	44 (41.53) ^{fg}	46 (42.69) ^e	50 (44.98) ^{cde}	46.67 (43.07) ^{ef}	46 (42.69) ^c	48 (43.84) ^c	51 (45.56) ^g	48.33 (44.03) ^{efg}
F test	*	*	*	*	*	*	*	*
SEM ±	(0.104)	(0.604)	(0.578)	(0.329)	(0.359)	(0.27)	(0.041)	(0.196)
CD ($p=0.05$)	(0.31)	(1.794)	(1.719)	(0.978)	(1.066)	(0.802)	(0.123)	(0.584)

*, Significant at 5% probability. Figures in parentheses are angular transformed values; Treatments with same alphabetical superscript within the column are statistically on par.

Table 3 Categorisation of chilli landraces based on mean per cent leaf curl index

Category	Mean per cent leaf curl index	Landraces	
		Number	Name
Highly resistant (HR)	0	0	-
Resistant (R)	0–10	0	-
Moderately resistant (MR)	11–25	3	UASBCF-27, UASBCF-29, UASBCF-30
Susceptible (S)	26–50	11	UASBCF-13, UASBCF-16, UASBCF-17, UASBCF-18, UASBCF-22, UASBCF-23, UASBCF-24, UASBCF-25, UASBCF-26 and UASBCF-32, Vellayani Samrudhi
Highly susceptible (HS)	51–100	7	Byadagi Kaddi, Byadagi Dabbi, UASBCF- 3, UASBCF-6, UASBCF10, UASBCF11 and UASBCF-15

or immunity to *S. dorsalis*. However, three landraces, namely UASBCF-27, UASBCF-29, and UASBCF-30, recorded comparatively lower mean LCI values of 22.83, 19.50, and 23.00%, respectively, and were categorised as moderately resistant. The reduced leaf curling indicated a greater capacity to tolerate or suppress thrips-induced injury. Eleven landraces, viz. UASBCF-13, UASBCF-16, UASBCF-17, UASBCF-18, UASBCF-22, UASBCF-23, UASBCF-24, UASBCF-25, UASBCF-26, UASBCF-32 and Vellayani Samrudhi, were classified as susceptible, recording mean LCI values ranging from 34.50–49.50% (Table 3). The remaining entries, including UASBCF-6, UASBCF-10, UASBCF-3, UASBCF-11, UASBCF-15, and the susceptible checks Byadagi Kaddi and Byadagi Dabbi, were categorised as highly susceptible, with LCI values ranging from 54.33–66.33% (Table 3). The observed variation in leaf curl severity suggests the presence of differential levels of partial resistance among the landraces, possibly mediated through morphological and biochemical traits influencing thrips feeding and damage expression. Similar findings have been reported by Gopal *et al.* (2019) and Mohan Rao and Anilkumar (2020).

Role of morphological traits in thrips resistance

Trichome density: Significant variation in trichome density was observed among the chilli landraces on both adaxial and abaxial leaf surfaces during *rabi* 2024–25 and summer 2025 (Table 4 and 5). During *rabi* 2024–25, the moderately resistant landrace UASBCF-29 recorded the highest trichome density on both the abaxial (68.10 hairs/cm²) and adaxial (61.60 hairs/cm²) surfaces, followed by UASBCF-30 and UASBCF-27 (Table 4). In contrast, the highly susceptible landrace UASBCF-6 and the susceptible checks Byadagi Kaddi and Byadagi Dabbi exhibited the lowest trichome densities. Similar results were observed during summer 2025 (Table 5), wherein UASBCF-29 recorded the highest trichome density on the abaxial (67.50 hairs/cm) and adaxial (58.92 hairs/cm) surfaces, followed by UASBCF-30 and UASBCF-27, whereas UASBCF-6 and the susceptible checks recorded significantly lower values. The consistently higher trichome density in moderately resistant landraces and lower density in susceptible entries

indicated a strong negative association between trichome abundance and thrips infestation. Dense trichomes may act as a physical barrier by restricting insect movement, feeding, and oviposition, particularly on the abaxial leaf surface where thrips preferentially colonise. Similar negative relationships between trichome density and thrips incidence have been reported by Rajaram and Ramamurthy (2001), Rameash *et al.* (2015) and Megharaj *et al.* (2016).

Trichome length: Significant variation in trichome length was observed among the chilli landraces during both *rabi* 2024–25 and summer 2025 (Table 4 and 5). During *rabi* 2024–25, the moderately resistant landrace UASBCF-29 recorded the longest trichomes on both the abaxial (0.60 mm) and adaxial (0.59 mm) leaf surfaces, followed by UASBCF-30 and UASBCF-27. In contrast, the highly susceptible landrace UASBCF-6 and the susceptible checks exhibited comparatively shorter trichomes. Similar trends were observed during summer 2025, wherein UASBCF-29 again recorded the maximum trichome length, while UASBCF-6 and the susceptible checks recorded the minimum values (Table 4 and 5, Supplementary Fig. 2 A and B). The association of longer trichomes with moderately resistant landraces suggests their role in reducing thrips infestation by acting as a physical barrier to insect movement and feeding. Together with higher trichome density, increased trichome length may contribute to constitutive resistance against *S. dorsalis*. Similar findings highlighting the importance of trichome architecture in pest resistance have been reported by Arati *et al.* (2008) and Megharaj *et al.* (2016).

Epicuticular wax load: Epicuticular wax content varied significantly among the chilli landraces during both seasons (Table 6). During *rabi* 2024–25, UASBCF-29 recorded the highest wax content (31.27 µg/dm²), followed by UASBCF-30 (29.07 µg/dm²) and UASBCF-27 (26.05 µg/dm²), whereas UASBCF-6 (14.05 µg/dm²) and the susceptible checks Byadagi Kaddi (9.60 µg/dm²) and Byadagi Dabbi (11.00 µg/dm²) recorded the lowest values. A similar trend was observed during summer 2025, with UASBCF-29 (33.37 µg/dm²), UASBCF-30 (30.20 µg/dm²), and UASBCF-27 (27.04 µg/dm²) exhibiting higher wax deposition, while UASBCF-6 and the susceptible

Table 4 Trichome characters and categorisation of chilli landraces during *rabi* 2024–25

Landraces	Category of resistance	Avg. no. thrips [@]	Trichome density (No. of hairs/cm ²)			Trichome length (mm)		
			Abaxial surface	Adaxial surface	Avg.	Abaxial surface	Adaxial surface	Avg.
UASBCF-27	MR	9.20	61.42	52.19	56.81	0.57	0.55	0.56
UASBCF-29		8.00	68.10	61.60	64.85	0.60	0.59	0.60
UASBCF-30		8.90	64.78	55.76	60.27	0.59	0.56	0.58
UASBCF-16	S	15.70	47.80	38.22	43.01	0.50	0.48	0.49
UASBCF-22		13.50	50.88	39.11	45.00	0.52	0.48	0.50
UASBCF-25		10.10	57.65	42.87	50.26	0.55	0.50	0.53
UASBCF-6	HS	21.10	43.70	28.10	35.90	0.42	0.39	0.41
UASBCF-10		18.00	47.55	32.43	39.99	0.44	0.42	0.43
UASBCF-11		17.70	48.65	35.70	42.18	0.45	0.45	0.45
Byadagi Kaddi	CHECK	19.25	11.85	34.05	22.95	0.31	0.33	0.32
Byadagi Dabbi		21.95	15.60	31.20	23.40	0.32	0.35	0.34
Vellayani Samrudhi		13.50	53.20	45.90	49.55	0.56	0.52	0.54
F test			*	*		*	*	
SEM ±			2.317	2.054		0.023	0.022	
CD (<i>p</i> =0.05)			6.84	6.062		0.069	0.066	

[@]from three young shoots (during flowering stage of *rabi* 2024). *, Significant at 5% probability; HS, Highly susceptible; S, Susceptible; MR, Moderately resistant.

Table 5 Trichome characters and categorisation of chilli landraces during summer 2024–25

Landraces	Category of resistance	Avg. No. thrips [@]	Trichome density (No. of hairs/cm ²)			Trichome length (mm)		
			Abaxial surface	Adaxial surface	Avg.	Abaxial surface	Adaxial surface	Avg.
UASBCF-27	MR	10.20	60.00	52.37	56.19	0.56	0.55	0.56
UASBCF-29		9.30	67.50	58.92	63.21	0.62	0.59	0.61
UASBCF-30		10.10	63.96	53.79	58.88	0.59	0.57	0.58
UASBCF-16	S	17.90	47.43	36.99	42.21	0.49	0.47	0.48
UASBCF-22		15.00	49.06	37.98	43.52	0.51	0.50	0.51
UASBCF-25		11.90	58.43	43.28	50.86	0.55	0.54	0.55
UASBCF-6	HS	24.30	42.23	26.16	34.20	0.43	0.41	0.42
UASBCF-10		20.10	46.30	30.85	38.58	0.45	0.43	0.44
UASBCF-11		20.00	47.59	33.91	40.75	0.46	0.44	0.45
Byadagi Kaddi	CHECK	22.30	12.30	36.00	24.15	0.38	0.40	0.39
Byadagi Dabbi		25.10	14.15	35.30	24.73	0.36	0.37	0.37
Vellayani Samrudhi		15.50	55.54	44.65	50.10	0.56	0.53	0.55
F test			*	*		*	*	
SEM ±			2.283	2.055		0.023	0.023	
CD (<i>p</i> =0.05)			6.738	6.065		0.067	0.068	

[@]from three young shoots (during flowering stage of summer 2025). *, Significant at 5% probability; HS, Highly susceptible; S, Susceptible; MR, Moderately resistant.

Table 6 Correlation coefficient (r) of incidence of thrips with morphological characters of chilli landraces

Variables	Morphological characters		
	Trichome density (No. of hairs/cm ²)	Trichome length (mm)	Epicuticular wax load (µg/dm ²)
Correlation with mean number of thrips	-0.934	-0.935	-0.920

checks recorded the lowest wax content. The higher wax accumulation observed in moderately resistant landraces and lower wax deposition in susceptible entries indicate a strong association between epicuticular wax and resistance to *S. dorsalis*. Epicuticular wax may contribute to resistance by modifying leaf surface characteristics, thereby reducing insect adhesion, feeding, and host acceptance. Similar associations between wax deposition and resistance to sucking pests have been reported by Mohan Rao and Anilkumar (2020) and Isabella *et al.* (2020).

Correlation analysis revealed strong and highly significant negative associations between thrips incidence and all morphological traits studied (Table 6, Fig. 1 and 2). Thrips population was negatively correlated with trichome density ($r = -0.934$), trichome length ($r = -0.935$), and epicuticular wax load ($r = -0.920$), with all correlations being significant at the 0.05 probability level. These results indicate that increased trichome density, longer trichomes, and higher wax deposition contribute substantially to resistance against *S. dorsalis*. The strong negative correlations further suggest that resistance is governed by the combined action of multiple morphological traits rather than a single mechanism. The simultaneous presence of dense and elongated trichomes along with greater epicuticular wax deposition likely creates an unfavourable surface environment for thrips colonisation, feeding, and reproduction. Similar findings on integrated resistance mechanisms in chilli have been reported by Rao *et al.* (2021).

Implications for breeding and pest management: Although complete resistance was not identified, UASBCF-27, UASBCF-29, and UASBCF-30 consistently exhibited moderate resistance across seasons, highlighting their potential as donor parents in chilli breeding programmes. Their lower thrips incidence and leaf curl index suggest the presence of stable heritable resistance factors. Morphological traits such as trichome density, trichome length, and epicuticular wax load may serve as reliable phenotypic markers for indirect selection of thrips-

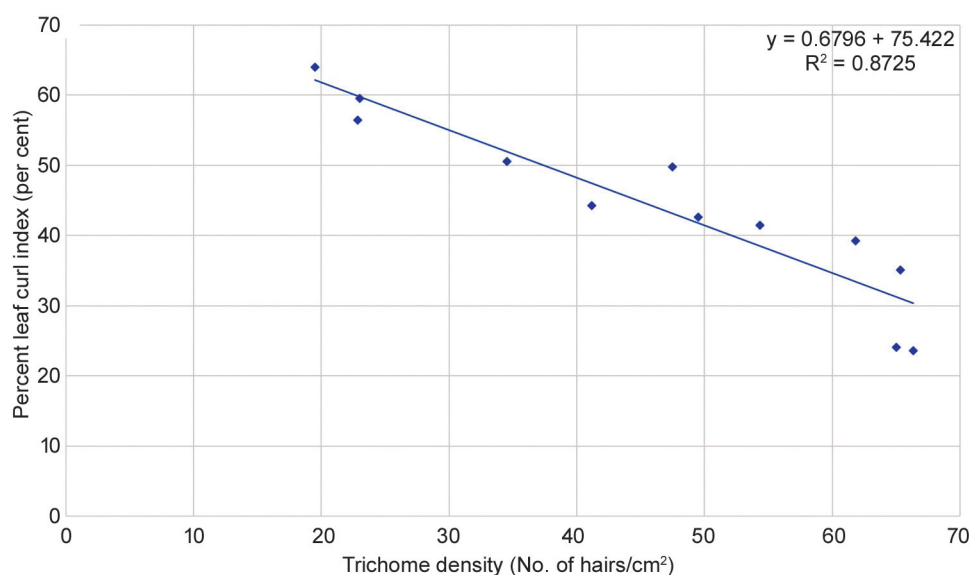


Fig. 1 Correlation between per cent leaf curl index and trichome density of landraces.

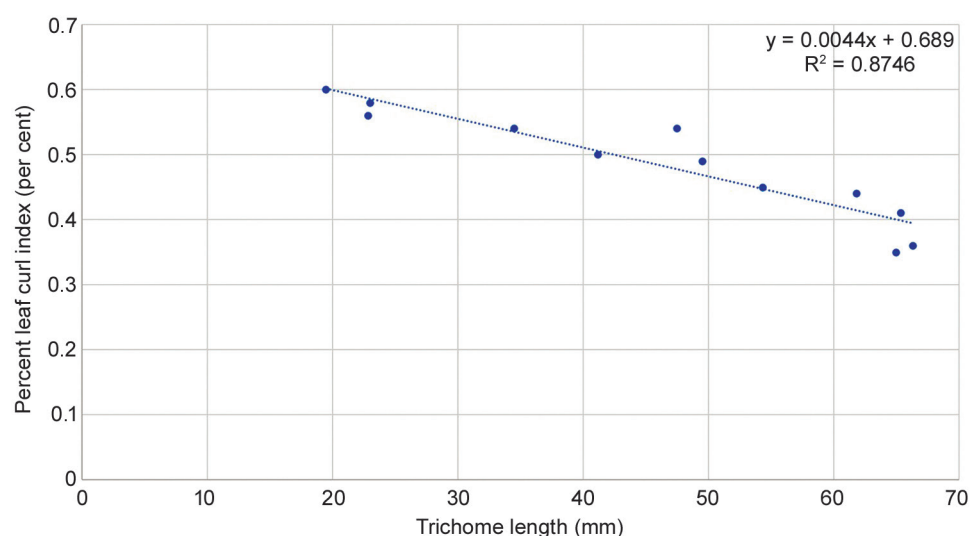


Fig. 2 Correlation between per cent leaf curl index and trichome length of landraces.

resistant genotypes. The incorporation of these traits into high-yielding cultivars could facilitate the development of durable resistant varieties and reduce reliance on chemical insecticides. Furthermore, these landraces represent valuable genetic resources for molecular breeding, quantitative trait loci mapping, and marker-assisted selection aimed at improving host plant resistance against *S. dorsalis* (Karim *et al.* 2021, Mohan Rao and Anilkumar 2020, Herath *et al.* 2021).

The present investigation demonstrated significant genetic variation for resistance to chilli thrips, *S. dorsalis*, among the evaluated bird's eye chilli landraces. UASBCF-29, UASBCF-30, and UASBCF-27 consistently exhibited moderate resistance across both seasons, recording lower thrips populations and leaf curl indices than susceptible entries. Their resistance was strongly associated with higher trichome density, longer trichomes, and greater epicuticular wax deposition. Correlation analysis revealed significant negative relationships between thrips incidence and trichome density ($r = -0.934$), trichome length ($r = -0.935$), and epicuticular wax load ($r = -0.920$), highlighting the importance of these traits in reducing thrips infestation. The combined action of these morphological characteristics likely impedes thrips colonisation, feeding, and damage expression. The results indicate that trichome density, trichome length, and epicuticular wax load can serve as reliable phenotypic markers for resistance screening and breeding. Therefore, UASBCF-27, UASBCF-29, and UASBCF-30 represent promising donor sources for developing thrips-resistant chilli cultivars and strengthening sustainable pest management strategies with reduced reliance on chemical insecticides.

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