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Morphological basis of resistance in chilli (*Capsicum annuum* L.) hybrids against black Thrips, *Thrips parvispinus* (Karny)

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Abstract
The present investigation was conducted at the Department of Agricultural Entomology, "A" Block, College of Agriculture, V. C. Farm, Mandya, Karnataka during Summer 2024 to elucidate the morphological basis of resistance in chilli (*Capsicum annuum* L.) hybrids against black thrips, *Thrips parvispinus* (Karny). Thrips infestation exhibited strong negative correlations with plant height (r = -0.88**), plant spread (r = -0.46**), number of primary branches (r = -0.95**), fruits per plant (r = -0.61**), and pedicle length (r = -0.60**), indicating these traits significantly enhance resistance. Other traits such as leaf shape, leaf colour, fruit and flower position, and floral colours varied among hybrids but showed no significant association with thrips incidence. These findings emphasize the role of key morphological features as reliable markers for breeding thrips-resistant chilli hybrids. Integrating these traits into resistance breeding programs can accelerate the development of resilient cultivars, promoting sustainable chilli production and effective pest management.

Keywords: *Capsicum annuum*, Black thrips, *Thrips parvispinus*, chilli, morphological resistance, leaf curl incidence

Introduction
Chilli (*Capsicum annuum* L.) is an economically important crop widely cultivated for its culinary and commercial value (Singh and Sharma, 2015) [36]. However, its production is severely constrained by infestations of thrips, particularly the black thrips, *Thrips parvispinus* (Karny), which cause significant damage by feeding on leaves and fruits, leading to reduced yield and quality (Reddy *et al*., 2010; Singh *et al*., 2018) [31, 37]. Understanding the morphological traits that contribute to host plant resistance against *T. parvispinus* is critical for developing resistant chilli hybrids (Maharijaya *et al*., 2011) [20]. Previous studies have demonstrated that resistance in *Capsicum* species can be influenced by both chemical and structural factors, with specific plant traits affecting thrips preference and infestation levels (Visschers *et al*., 2019; Haerul *et al*., 2020) [45, 13]. Morphological characters such as plant height, branching pattern, and fruit traits have been linked to variations in thrips susceptibility, providing potential markers for resistance breeding (Mound and Marullo, 1996; Maharijaya *et al*., 2011) [23, 20]. Investigating these traits offers a sustainable approach to integrated pest management by enabling the selection of chilli cultivars with inherent resistance to black thrips, thereby reducing reliance on chemical control and enhancing crop productivity (Smith, 2012; Carriger *et al*., 2006) [38, 9].

Materials and Methods
The present study was conducted at the Department of Agricultural Entomology and "A" Block, College of Agriculture, V. C. Farm, Mandya, Karnataka, during Summer 2024, to investigate the morphological basis of resistance in chilli hybrids against black thrips, *Thrips parvispinus* (Karny), by evaluating key morphological traits and their correlation with pest incidence under field conditions.

Plant morphological characters
Five un-infested plants from each resistance category were evaluated for morphological traits

at 100-120 days after transplanting, following the IPGRI (1995) [17] Capsicum descriptors.

1. **Plant Height:** Measured in cm using a meter scale; average height of five tagged plants recorded.
2. **Plant Spread:** Measured at the widest point in cm; average of five plants recorded.
3. **Number of Primary Branches:** Counted on the main axis of five plants; average calculated.
4. **Number of Fruits per Plant:** Total fruits harvested per plant during the season; average calculated.
5. **Pedicel Length:** Average length of five mature fruits measured at marketable stage.
6. **Plant Growth Habit:** Classified at 50% fruit ripening as Prostrate, Intermediate (compact), or Erect.
7. **Leaf Shape:** Noted as Deltoid, Ovate, or Lanceolate from 10 mature leaves at 50% fruit ripening.
8. **Leaf Colour:** Recorded from 10 mature leaves per plant at 50% fruit ripening; categories included yellow, light green, green, dark green, purple, variegated, etc.
9. **Flower Position:** Observed at anthesis; classified as pendant, intermediate, or erect.
10. **Fruit Position:** Recorded as pendent or erect on five plants.
11. **Fruit Shape:** Categorized as elongate, round, triangular, campanulate, blocky, or other.
12. **Flower Colour:** Noted at anthesis; white, light yellow, yellow, yellow-green, etc.
13. **Corolla Colour:** Recorded as white, light yellow, yellow, yellow-green, purple, or other.
14. **Anther Colour:** Observed immediately after blooming; recorded as white, yellow, pale blue, blue, or purple.

Statistical analysis: The mean values of plant morphological characters for each test hybrid, categorized by resistance level, were calculated and subjected to analysis of variance (ANOVA) following the procedures outlined by Gomez and Gomez (1984) [12] and Hosmand (1988) [15]. Prior to analysis, percentage data were transformed using the arcsine transformation to meet ANOVA assumptions. Mean comparisons were performed using Tukey's Honestly Significant Difference (HSD) test (Tukey, 1965) [42] for tabulation and interpretation**.**

Results and Discussion

Plant height

The evaluation of chilli hybrids revealed that resistant genotypes exhibited significantly greater plant height compared to moderately resistant, susceptible, and highly susceptible categories. Specifically, Iravata (98.33 cm) and Meenakshi (95.91 cm) demonstrated the highest plant stature and were classified as resistant. Moderately resistant hybrids such as Kalavathi (91.56 cm) and Dolphin (50.93 cm) showed intermediate plant heights, whereas moderately susceptible and susceptible hybrids ranged between 85.34 cm and 89.30 cm. The susceptible check, Byadagi Kaddi, recorded the lowest plant height of 84.45 cm (Table 1; Figure 1).

Correlation analysis indicated a strong and significant negative relationship between percent leaf curl index and plant height (r = -0.88**), suggesting that increased plant height confers enhanced resistance to *Thrips parvispinus* infestation (Table 2). This observation is consistent with earlier findings that plant height is predominantly governed by genetic potential but is also influenced by environmental conditions such as optimal temperature regimes conducive to vegetative growth (Aloni *et al*., 1999; Bhagyalakshami *et al*., 1990; Erard *et al*., 2002) [3, 6, 11]. Comparable variability in plant height among chilli cultivars has been documented by Abdullah *et al*. (2003) and Sreelathakumary and Rajamony (2004). Furthermore, Sandeep *et al*. (2008) [1, 40, 32] reported that resistant chilli genotypes exhibited significantly greater plant height relative to susceptible ones, reinforcing the role of plant stature as a reliable morphological marker for thrips resistance. Collectively, these findings underscore the importance of incorporating plant height as a selection criterion in breeding programs aimed at enhancing resistance against *T. parvispinus*.

Plant spread

Among the chilli hybrids evaluated, resistant genotypes exhibited greater plant spread compared to moderately resistant, susceptible, and highly susceptible groups. The highest plant spread was recorded in Iravata (86.49 cm), followed closely by Meenakshi (83.15 cm), both classified as resistant hybrids. Moderately resistant hybrids Kalavathi (85.50 cm) and Dolphin (85.33 cm) showed slightly lower spread, while moderately susceptible hybrids Rakshak, Praveen, and Pithamber ranged between 78.80 cm and 85.35 cm. Susceptible hybrids such as Akshaya-22, ARD-5555, and ARD-499 had plant spreads from 68.22 cm to 77.33 cm, comparable to moderately susceptible hybrids. Highly susceptible hybrids Kavitha and KGF-2 recorded spreads of 81.30 cm and 76.75 cm, respectively, whereas the susceptible check Byadagi Kaddi had the lowest spread of 71.51 cm (Table 1; Figure 1).

Correlation analysis revealed a significant negative association between percent leaf curl index and plant spread (r = -0.46**), indicating that wider plant spread is linked to reduced thrips infestation (Table 2). Variation in plant spread is influenced by genetic factors and environmental conditions, including soil and agro-climatic factors, as well as indirectly by the number of primary branches per plant (Nehru *et al*., 2003; Smitha and Basavaraja, 2006; Mahantesh *et al*., 2013; Sharma *et al*., 2015) [25, 45, 19, 36]. Herison *et al*. (2014) reported similar findings in chilli hybrids, where resistant genotypes exhibited, greater plant spread compared to susceptible ones, supporting the present study's observations. These results suggest plant spread as a valuable morphological trait for screening and breeding chilli hybrids with enhanced resistance to *Thrips parvispinus*.

Table 1: Plant morphological characters associated with resistance against chilli black thrips, *T. parvispinus* at 120 DAT during, *Summer* 2024

Sl. No.	Category	Hybrids	Percent leaf curl index PLI (%)	Plant height (cm)	Plant spread (cm)	Number of primary branches (Per plant)	Number of fruits (Per plant)	Pedicel length (cm)
1	R	Iravata	6.00 (14.18)	98.33^{a}	86.49^{a}	9.93^{a}	78.55^{a}	2.19^{d}
2		Meenakshi	6.67 (14.97)	95.91^{a}	83.15^{bc}	9.49^{ab}	71.61^{h}	2.87^{ab}
3	MR	Kalavathi	15.67 (23.32)	91.56^{b}	85.50^{ab}	9.23^{ab}	76.44^{c}	3.00^{ab}
4		Dolphin	19.33(26.08)	90.56^{bc}	85.33^{g}	8.92^{bc}	75.37^{d}	2.84^{ab}
5	MS	Rakshak	23.67 (29.11)	89.30^{bcd}	84.58^{ab}	8.41^{cd}	74.42^{e}	2.75^{abc}
6		Praveen	28.00 (31.95)	88.79^{bcde}	85.35^{ab}	8.38^{cd}	69.80^{i}	3.09^{a}
7		Pithamber	30.00(33.21)	87.56^{cdef}	78.80^{d}	8.16^{cde}	71.43^{h}	2.91^{ab}
8	S	Akshaya-22	34.33 (35.87)	87.48^{cdef}	77.33^{d}	8.09^{def}	73.59^{f}	2.55^{bcd}
9		ARD-5555	38.33 (38.25)	86.71^{def}	74.33^{e}	7.83^{defg}	73.53^{f}	2.85^{ab}
10		ARD-499	44.33 (41.74)	85.82^{def}	68.22^{g}	7.56^{efg}	71.46^{h}	2.58^{bcd}
11	HS	Kavitha	57.33 (48.64)	85.47^{ef}	81.30^{c}	7.33^{fg}	68.66^{j}	2.76^{abc}
12		KGF-2	56.67 (48.83)	85.34^{ef}	76.75^{de}	7.23^{g}	69.81^{i}	2.35^{cd}
13	SC	Byadagi kaddi	68.87 (56.09)	84.45^{f}	71.51^{f}	7.11^{g}	72.45^{g}	2.62^{bcd}
SE m±			2.81	0.15	2.81	0.13	0.13	0.10
CD @ p = 0.05			8.54	0.46	8.54	0.40	0.41	0.33

Figures in the parenthesis indicate arcsine transformed values; Values in the column followed by common letters are non-significant at p = 0.05 as per Tukey's HSD (Tukey, 1965); R-Resistant; MR-Moderately resistant; MS-Moderately susceptible; S-Susceptible; SC-Susceptible check; No-number.

Number of primary branches (per plant)

The number of primary branches per plant, which correlates positively with plant spread and influences optimal plant spacing for maximizing fruit yield, varied significantly among the tested chilli hybrids, ranging from 7.11 to 9.93 branches per plant. Resistant hybrids exhibited a higher number of primary branches compared to moderately resistant, susceptible, and highly susceptible groups. Iravata (9.93 branches) and Meenakshi (9.49 branches) recorded the highest values and were classified as resistant. Moderately resistant hybrids Kalavathi (9.23) and Dolphin (8.92) showed intermediate branching, while moderately susceptible hybrids Rakshak, Praveen, and Pithamber ranged between 8.16 and 8.41 branches. Susceptible hybrids Akshaya-22, ARD-5555, and ARD-499 had 7.56 to 8.09 branches, comparable to moderately susceptible types. Highly susceptible hybrids Kavitha and KGF-2 recorded 7.23 and 7.33 branches, respectively, with the susceptible check Byadagi having the lowest count of 7.11 branches (Table 1; Figure 1).

Correlation analysis demonstrated a strong and significant negative association between percent leaf curl index and number of primary branches (r = -0.95**), indicating that plants with more branches tend to exhibit greater resistance to *T. parvispinus* infestation (Table 2). This variation in branching is influenced by genetic factors, environmental interactions, and soil conditions, consistent with previous findings in chilli (Smitha and Basavaraja, 2006; Ukkund *et al*., 2007; Sandeep *et al*., 2008; Pramila *et al*., 2009; Amit *et al*., 2014; Vijaya *et al*., 2014) [45, 43, 32, 30, 4, 44]. Amit *et al*. (2014) [44] reported a wide range in primary branch number among 23 chilli genotypes, with the resistant hybrid 'Pusa Sadabahar' exhibiting the highest average (10.62 branches) and the highly susceptible 'PCB-08-CH' the lowest (4.70 branches), corroborating the present study's results. These findings highlight the number of primary branches as a critical morphological trait associated with thrips resistance, which can be effectively utilized in breeding programs targeting enhanced pest resilience in chilli.

Number of fruits (per plant)

The number of fruits per plant among the selected chilli hybrids varied significantly, ranging from 68.66 to 78.55. Resistant hybrids recorded a higher fruit number compared to moderately resistant, susceptible, and highly susceptible groups. Iravata (78.55 fruits) and Meenakshi (71.61 fruits) exhibited the highest fruit counts and were categorized as resistant. Moderately resistant hybrids Kalavathi (76.44) and Dolphin (75.37) showed slightly lower fruit numbers, followed by moderately susceptible hybrids Rakshak, Praveen, and Pithamber with 69.80 to 74.42 fruits. Susceptible hybrids Akshaya-22, ARD-5555, and ARD-499 ranged between 71.46 and 73.59 fruits, comparable to moderately susceptible types. Highly susceptible hybrids Kavitha and KGF-2 recorded 68.66 and 69.81 fruits, respectively, while the susceptible check Byadagi Kaddi had 72.45 fruits per plant (Table 1; Figure 1).

Correlation analysis revealed a significant negative association between percent leaf curl index and number of fruits per plant (r = -0.61**), indicating that higher fruit numbers are linked to reduced thrips infestation (Table 2). Variation in fruit yield is influenced by the number of fruits per plant, fruit length, and fruit weight, which positively correlate with overall yield, as reported by Sharma *et al*. (2010) [34], Chattopadhyay *et al*. (2011) [10], and Tembhurne *et al*. (2008) [41]. Additionally, Vijaya *et al*. (2014) [44] observed that resistant chilli genotypes produced a significantly higher number of fruits per plant compared to susceptible ones, exemplified by genotypes 'Sankeshwar' and 'LCA-206' with 186.30 and 176.53 fruits respectively, while the highly susceptible 'CKBL' recorded only 49.63 fruits.

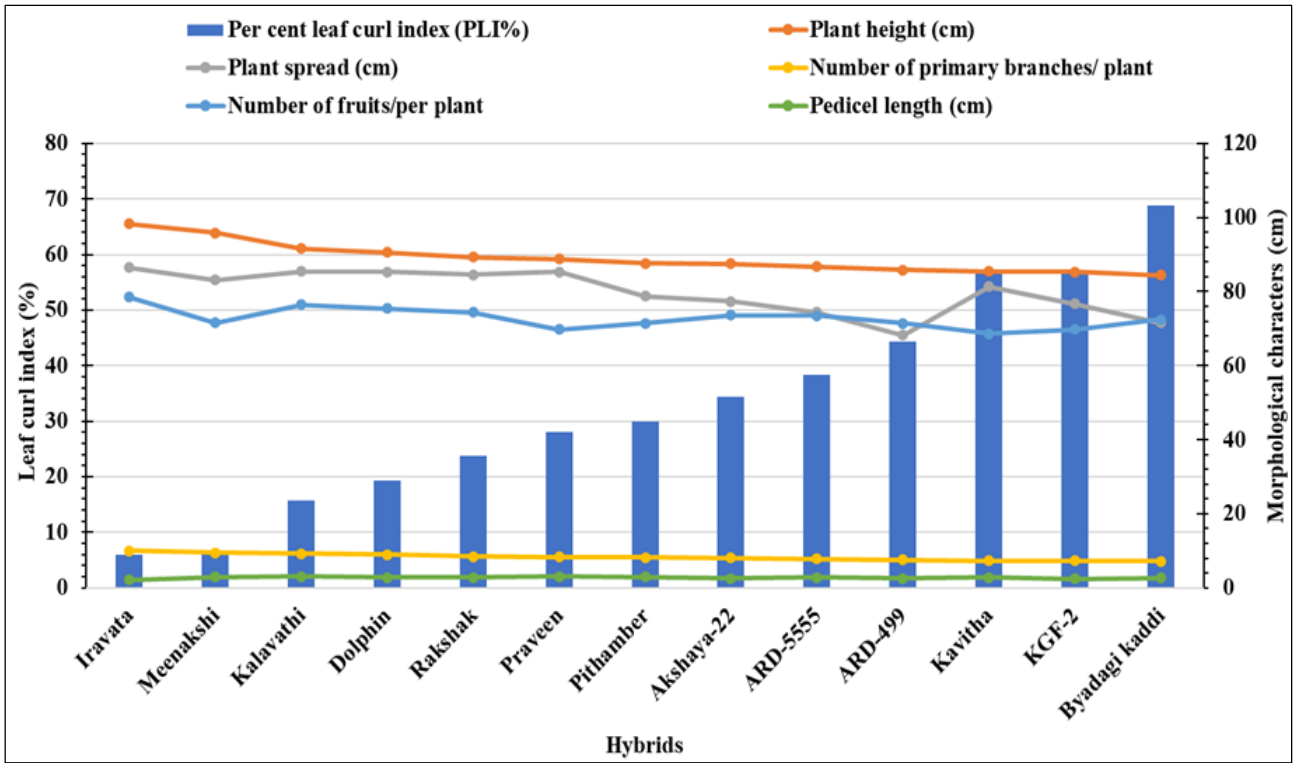

Fig 1: Relationship between morphological characters and percent leaf curl index at 120 DAT during, *Summer* 2024

Table 2: Correlation matrix between PLI and plant morphological characters associated with resistance against chilli black thrips, *T. parvispinus* at 120 DAT during, *Summer* 2024

Parameters	Y-PLI (%)	X_1	X_2	X_3	X_4	X_5	R^2 Value
Y-PLI (%)	1.000	-0.881**	-0.462**	-0.953**	-0.612**	-0.601**	0.939
X_1-Plant height (cm)		1.000	0.523**	0.965**	0.633**	0.751**	
X_2-Plant spread (cm)			1.000	0.493**	0.127	0.592**	
X_3-Number of primary branches/plants				1.000	0.692**	0.691**	
X_4-Number of fruits/plants					1.000	0.484**	
X_5-Length of pedicle (cm)						1.000	

N = 13; ** Significant at $P \leq 0.01$; PLI-Percent leaf curl index

Length of pedicle

Among the selected chilli hybrids, pedicel length varied significantly from 2.19 cm to 3.09 cm. Resistant hybrids generally exhibited longer pedicels compared to moderately resistant, susceptible, and highly susceptible hybrids. Iravata (2.19 cm) and Meenakshi (2.87 cm) recorded the highest pedicel lengths and were categorized as resistant. Moderately resistant hybrids Kalavathi (3.00 cm) and Dolphin (2.84 cm) showed intermediate pedicel lengths, while moderately susceptible hybrids Rakshak, Praveen, and Pithamber ranged from 2.75 cm to 3.09 cm. Susceptible hybrids Akshaya-22, ARD-5555, and ARD-499 had pedicel lengths between 2.55 cm and 2.85 cm, comparable to moderately susceptible types. Highly susceptible hybrids Kavitha and KGF-2 recorded 2.76 cm and 2.35 cm, respectively, with the susceptible check Byadagi Kaddi measuring 2.62 cm (Table. 1).

Correlation analysis revealed a significant negative association between percent leaf curl index and pedicel length (r = -0.60**), indicating that longer pedicels are associated with reduced thrips infestation (Table 2). This finding aligns with Murmu *et al*. (2017) [24], who reported that the resistant chilli genotype AC-573 exhibited the longest pedicel length (3.42 cm), whereas the highly susceptible genotype CGN-19212 had the shortest (2.07 cm).

Plant growth habit

Among the selected chilli hybrids, plant growth habit was observed to vary primarily between intermediate and dense types. Resistant hybrids such as Iravata and Meenakshi exhibited both intermediate and dense growth habits. Similarly, moderately resistant hybrids Kalavathi and Dolphin showed dense and intermediate growth habits, respectively. Moderately susceptible hybrids Rakshak, Praveen, and Pithamber displayed intermediate, dense, and intermediate growth habits, respectively. Susceptible hybrids Akshaya-22, ARD-5555, and ARD-499 also exhibited a mix of intermediate and dense growth habits. Highly susceptible hybrids Kavitha and KGF-2 were characterized by intermediate and dense growth habits, respectively, while the susceptible check Byadagi Kaddi showed an intermediate growth habit (Table 3).

Previous studies have highlighted that plant growth habit influences microclimatic conditions within the canopy, which can affect pest colonization and development (Smith and Clement, 2012) [38]. Dense growth habit may create a more humid environment, potentially favoring or deterring pest populations depending on the pest species (Maharijaya *et al*., 2011) [20]. In chilli, growth habit variation has been linked to genetic diversity and has implications for resistance breeding, as compact growth forms may reduce pest access or alter pest behavior (Visschers *et al*., 2019) [45].

Understanding these morphological variations provides valuable insights for selecting genotypes with growth habits less conducive to thrips infestation, thereby contributing to integrated pest management strategies.

Leaf shape

Among the selected chilli hybrids, leaf shape varied predominantly between ovate and lanceolate forms. Resistant hybrids Iravata and Meenakshi exhibited ovate and lanceolate leaf shapes, respectively. Moderately resistant hybrids Kalavathi and Dolphin both displayed ovate leaves. In moderately susceptible hybrids, Rakshak and Praveen had lanceolate leaves, while Pithamber showed ovate leaves. Susceptible hybrids Akshaya-22 and ARD-5555 possessed lanceolate leaves, whereas ARD-499 had ovate leaves. Highly susceptible hybrids Kavitha and KGF-2 exhibited lanceolate and ovate leaf shapes, respectively, while the susceptible check Byadagi Kaddi recorded lanceolate leaves (Table 3).

Correlation analysis revealed a significant positive association between percent leaf curl index and lanceolate leaf shape, suggesting that this leaf morphology may be linked to increased susceptibility to thrips infestation. The present study confirms the presence of both lanceolate and ovate leaf shapes among diverse chilli genotypes. This contrasts with previous reports where only lanceolate leaves were documented by Padma *et al*. (2017) [28] and Santhosha *et al*. (2019) [33], while Orobiya *et al*. (2017) [47] reported both deltoid and lanceolate leaf shapes in chilli.

Leaf colour

Among the selected chilli hybrids, leaf colour exhibited considerable variation, including yellow, light green, green, dark green, light purple, purple, variegated, and other shades. Resistant hybrids Iravata and Meenakshi displayed green and dark green leaf colours, respectively. Moderately resistant hybrids Kalavathi and Dolphin both had green leaves. Among moderately susceptible hybrids, Rakshak and Pithamber showed dark green leaves, while Praveen had green leaves. Susceptible hybrids Akshaya-22, ARD-5555, and ARD-499 exhibited green and dark green leaf colours. Highly susceptible hybrids Kavitha and KGF-2 had green and dark green leaves, respectively, while the susceptible check Byadagi Kaddi recorded dark green leaves (Table 3).

Table 3: Plant morphological characters associated with resistance against chilli black thrips, *T. parvispinus* at 120 DAT during, *Summer* 2024

Sl. No.	Category	Hybrids	Per cent leaf curl index PLI (%)	Plant growth habit	Leaf shape	Leaf colour	Fruits per axil
1	R	Iravata	6.00 (14.18)	Intermediate	Ovate	Green	Pendent
2		Meenakshi	6.67 (14.97)	Dense	Lanceolate	Dark green	Solitary
3	MR	Kalavathi	15.67 (23.32)	Dense	Ovate	Green	Cluster
4		Dolphin	19.33 (26.08)	Intermediate	Ovate	Green	Cluster
5	MS	Rakshak	23.67 (29.11)	Intermediate	Lanceolate	Dark green	Cluster
6		Praveen	28.00 (31.95)	Dense	Lanceolate	Green	Solitary
7		Pithamber	30.00 (33.21)	Intermediate	Ovate	Dark green	Cluster
8	S	Akshaya-22	34.33 (35.87)	Intermediate	Lanceolate	Green	Solitary
9		ARD-5555	38.33 (38.25)	Dense	Lanceolate	Dark green	Solitary
10		ARD-499	44.33 (41.74)	Intermediate	Ovate	Dark green	Cluster
11	HS	Kavitha	57.33 (48.64)	Intermediate	Lanceolate	Green	Solitary
12		KGF-2	56.67 (48.83)	Dense	Ovate	Dark green	Cluster
13	SC	Byadagi kaddi	68.87 (56.09)	Intermediate	Lanceolate	Dark green	Cluster
SE m±			2.81				
CD @ p = 0.05			8.54				

Figures in the parenthesis indicate arcsine transformed values; Values in the column followed by common letters are non-significant at *p*=0.05 as per Tukey's HSD (Tukey, 1965); R-Resistant; MR-Moderately resistant; MS-Moderately susceptible; S-Susceptible; SC-Susceptible check; No-number.

In total, six hybrids possessed green leaf colour, and seven exhibited dark green, indicating variability in green pigmentation intensity across genotypes. This variation aligns partially with findings by Padma *et al*. (2017) [28], who reported differences in leaf colour among chilli genotypes, and Santhosha *et al*. (2019) [33], who also documented leaf colour diversity within *Capsicum annuum*.

Fruits per axil

Among the selected chilli hybrids, fruits per axil were observed in three forms: pendent, solitary, and cluster. Resistant hybrids Iravata and Meenakshi exhibited pendent and solitary fruits per axil, respectively. Moderately resistant hybrids Kalavathi and Dolphin both showed cluster fruiting per axil. In moderately susceptible hybrids, Rakshak and Pithamber had cluster fruits per axil, while Praveen exhibited solitary fruits. Susceptible hybrids Akshaya-22 and ARD-5555 showed solitary fruits per axil, whereas ARD-499 had cluster fruits. Highly susceptible hybrids Kavitha and KGF-2 displayed solitary and cluster fruiting, respectively, with the susceptible check Byadagi Kaddi recording cluster fruits per axil (Table 3).

The number of fruits per plant depends largely on the number of flowers produced and the percentage of fruit set, which are influenced by genetic factors, crop management practices, and environmental conditions during the growing season. The present study revealed considerable variation in fruiting patterns among hybrids, indicating substantial potential for selecting elite genotypes based on this trait.

Previous studies have documented wide variability in fruit number per plant, with Kerketta *et al*. (2018) [48] reporting a range from 35.67 to 205.25 fruits per plant, and Bantu and Kokkanti (2019) [5] observing 77.50 to 389.50 fruits per plant. Similar findings were reported by Sandeep *et al*. (2008) [32], Ajjappalavara and Channagoudra (2009) [2], Indu Arora *et al*. (2015) [16], Bijalwan and Madhvi (2013) [7], Yatagiri *et al*. (2017) [46], Katheek *et al*. (2018) [18], Mena *et al*. (2019) [21], and Ngullie and Biswas (2019), underscoring the significance of fruiting characteristics in chilli breeding for yield improvement.

Fruits position

Among the selected chilli hybrids, fruit position was observed as either pendent or erect. Resistant hybrids Iravata and Meenakshi exhibited pendent and erect fruit positions, respectively. Moderately resistant hybrids Kalavathi and Dolphin showed erect and pendent

Table 4: Flower characters associated with resistance against chilli black thrips, *T. parvispinus* at 120 DAT during, *Summer* 2024

Sl. No.	Category	Hybrids	Per cent leaf curl index PLI (%)	Fruit position	Flower position	Flower colour	Corolla colour	Anther colour
1	R	Iravata	6.00 (14.18)	Pendent	Pendent	White	White	White
2		Meenakshi	6.67 (14.97)	Erect	Erect	White	White	White
3	MR	Kalavathi	15.67 (23.32)	Erect	Erect	White	White	White
4		Dolphin	19.33 (26.08)	Pendent	Pendent	White	White	White
5	MS	Rakshak	23.67 (29.11)	Erect	Erect	White	White	White
6		Praveen	28.00 (31.95)	Pendent	Pendent	White	White	White
7		Pithamber	30.00 (33.21)	Erect	Erect	White	White	White
8	S	Akshaya-22	34.33 (35.87)	Pendent	Pendent	White	White	White
9		ARD-5555	38.33 (38.25)	Erect	Erect	White	White	White
10		ARD-499	44.33 (41.74)	Pendent	Pendent	White	White	White
11	HS	Kavitha	57.33 (48.64)	Erect	Erect	White	White	White
12		KGF-2	56.67 (48.83)	Erect	Erect	White	White	White
13	SC	Byadagi kaddi	68.87 (56.09)	Pendent	Pendent	White	White	White
SE m±			2.81					
CD @ p = 0.05			8.54					

Figures in the parenthesis indicate arcsine transformed values; Values in the column followed by common letters are non-significant at *p*=0.05 as per Tukey's HSD (Tukey, 1965); R-Resistant; MR-Moderately resistant; MS-Moderately susceptible; S-Susceptible; SC-Susceptible check; No-number.

fruit positions, respectively. In moderately susceptible hybrids, Rakshak and Pithamber had erect fruit positions, while Praveen displayed pendent fruits. Susceptible hybrids Akshaya-22, ARD-5555, and ARD-499 exhibited pendent, erect, and erect fruit positions, respectively. Highly susceptible hybrid Kavitha had erect fruit position, whereas the susceptible check Byadagi Kaddi showed pendent fruit position (Table 4).

The present study recorded all three flower positions—erect, intermediate, and pendent—consistent with findings by Orobiyi *et al*. (2017) [27]. In contrast, Padma *et al*. (2017) [28] reported only intermediate and erect flower types, while Bantu and Kokkanti (2019) [5] observed pendent and erect positions in their chilli genotypes. The number of flowers per axil and their positional arrangement are critical not only for varietal identification but also for influencing cluster-bearing habits, which can affect fruit set and yield potential.

Flower position

Among the selected chilli hybrids, flower position varied as pendant, intermediate, or erect. Resistant hybrids Iravata and Meenakshi exhibited pendant and erect flower positions, respectively. Moderately resistant hybrids Kalavathi and Dolphin showed erect and pendant flower positions, respectively. In moderately susceptible hybrids, Rakshak and Pithamber had erect flower positions, while Praveen displayed pendant flowers. Susceptible hybrids Akshaya-22, ARD-5555, and ARD-499 exhibited pendant, erect, and erect flower positions, respectively. Highly susceptible hybrids Kavitha and KGF-2 showed erect flower positions, whereas the susceptible check Byadagi Kaddi recorded pendant flowers (Table 4).

The present study observed all three flower positions—erect, intermediate, and pendant—consistent with findings by Orobiyi *et al*. (2017) [27]. In contrast, Padma *et al*. (2017) [28] reported only intermediate and erect flower types, while Bantu and Kokkanti (2019) [5] documented pendant and erect flower positions in chilli genotypes. The number and position of flowers per axil are critical not only for varietal identification but also influence cluster-bearing habits, which can affect fruit set and overall yield.

Flower characters (flower colour, corolla colour, anther colour)

In the present study, all chilli hybrids across different resistance categories consistently exhibited white flower colour, corolla colour, and anther colour. This uniformity in floral pigmentation is a common characteristic in *Capsicum annuum* and has been reported widely in previous research (Table 4).

White flower colour and corolla pigmentation in chilli are genetically conserved traits, often linked to species identity and reproductive biology (Bosland & Votava, 2012) [8]. The white corolla serves as an attractant to pollinators, facilitating effective pollination and fruit set (Miller & Tanksley, 1990) [22]. Similarly, anther colour in chilli is predominantly white or pale yellow, which is typical for many *Capsicum* species and is associated with pollen viability and fertility (Pickersgill, 1997) [29].

Several studies corroborate these findings. For instance, Padma *et al*. (2017) [28] and Santhosha *et al*. (2019) [33] reported white flowers and corolla colour in diverse chilli genotypes, irrespective of their resistance status. Likewise, research by Orobiya *et al*. (2017) [47] confirmed that white floral parts are a stable morphological trait in *Capsicum* species. The lack of variation in flower, corolla, and anther colour suggests these traits are less influenced by environmental factors or pest resistance mechanisms but are rather genetically fixed within cultivated chilli germplasm.

While flower colour may not directly influence pest resistance, it plays a crucial role in reproductive success and hybridization potential, which are important considerations in breeding programs (Smith & Clement, 2012). Understanding the stability of these floral traits helps breeders maintain varietal purity and supports the development of hybrids with desired agronomic and resistance characteristics.

Conclusion

The present study highlights significant morphological variations among chilli (*Capsicum annuum* L.) hybrids with differing levels of resistance to *Thrips parvispinus*. Resistant hybrids such as Iravata and Meenakshi consistently exhibited superior traits including greater plant height, wider plant spread, higher number of primary branches, increased fruit number per plant, and longer pedicels compared to susceptible counterparts. Morphological characters like plant and leaf growth habit, leaf shape, fruit and flower positions also varied among hybrids and showed correlations with thrips resistance. Notably, lanceolate leaf shape demonstrated a positive association with susceptibility, while traits such as increased branching and plant stature were negatively correlated with leaf curl index, indicating enhanced resistance. Floral traits including flower, corolla, and anther colour remained uniformly white across all hybrids, suggesting genetic stability in these characters irrespective of resistance status. These findings corroborate previous research and underscore the importance of integrating key morphological markers in chilli breeding programs to develop thrips-resistant cultivars, thereby promoting sustainable pest management and improved crop productivity.

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Author Contribution Statement

Gaurav Vinod Rao Sadafale-Conceptualization, investigation, draft preparation and analysis;
L. Vijaykumar-Conceptualization, framed research proposal and draft correction;
N Kiran Kumar, G. Somu, Shivaray Navi and Nagesh Malasiddappa Chikkarugi-Writing, reviewing and editing of research article. All authors read and approved the manuscript.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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