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Screening of chilli genotypes against chilli thrips (*Scirtothrips dorsalis* Hood) and yellow mite [*Polyphagotarsonemus latus* (Banks)]

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Abstract
Investigations on screening of chilli genotypes against chilli thrips and mite were conducted at Karkipette of Chikmagalur district, Karnataka during March of 2015. Out of thirty one chilli genotypes screened against thrips and mites, none was found completely free from the attack of pests. The four genotypes, DCC-109, 185, 3 and DCC-89 were found moderately resistant, eleven genotypes, DCC-187, 177, 127, 103, 27, 20, 39, 15, 184, 239, 44, 48, 167, 230, 43, were found susceptible and two genotypes *viz*., DCC-66 and Byadgi Kaddi were found highly susceptible to both thrips and mite. The morphological and biochemical characters *viz*., trichome density, chlorophyll and phenol content were significantly negatively correlated with the population of thrips, mites and LCI. Further Moderately resistant genotypes showed thick and dark green colour leaves, very thin and light green colour leaves was observed in highly susceptible genotypes. The maximum fruit yield of chilli was also obtained in the DCC-109, 185, 3 followed by DCC-89.

Keywords: chilli, *Scirtothrips, Polyphagotarsonemus*, trichome density, chlorophyll, phenol content

1. Introduction

Chilli (*Capsicum annuum* L.) belongs to the family Solanaceae and is an important spice cum vegetable crop commonly used in Indian dietary. It is grown throughout the year as a cash crop and used in green and red ripe dried stage for its pungency, colour and other ingredients in all culinary preparations of rich and poor alike to impart taste, flavour and colour. It is also called as sweet pepper, bell pepper or green pepper. Nutritionally, it is a rich source of vitamin A, B and C. Capsaicin an alkaloid responsible for pungency in chillies has medicinal properties and it prevents heart attack by dilating the blood vessels (Gill, 1989) [9]. Chilli is one of the most popular and highly remunerative vegetable crops grown throughout the world. India is the largest consumer and exporter of chilli in the world with an area of 7.74 lakh ha and production of 14.92 lakh MT (NHB, 2015) [15]. The country commands a share of 25 per cent in global chilli trade and earns 375 million US dollar by exporting about 20 per cent of its production (Pednekar, 2015) [16]. In India, it is intensively cultivated in Andhra Pradesh, Maharashtra, Karnataka, Tamil Nadu, Rajasthan and in hilly areas of Uttar Pradesh (Ratnakumari *et al*., 2001) [18]. In Rajasthan, it is cultivated in an area of 12.21 thousand hectares with an annual production of 17.71 million tonnes (Anonymous, 2013) [4]. The major chilli growing districts of Karnataka includes Dharwad, Haveri, Belgaum, Gadag, Bellary, Gulbarga, Chikmagalur and Raichur district. In malanad belt of Chikmagalur, important varieties grown are Priyanka, Rudra, Pusa Jwala, Byadgi Local, Bhavani, Laxmi, Akra lohit, Sithara, Brahma, Thanaya, Garima *etc*. Various factors are responsible for low productivity and production of chilli that include adverse climate, poor quality seeds, diseases, insect and mite pests. The insects and mites are of prime importance which significantly affects both the quality and production of chilli. Chilli thrips, *Scirtothrips dorsalis* Hood and yeloow mite, *Polyphagotarsonemus latus* (Banks) are two serious pests of chilli (Ananthakrishnan, 1973, Amin, 1979) [3, 1] both in the nursery and main field. Adults and nymphs of *S. dorsalis* suck the sap from tender leaves and growing shoot. Affected leaves curl either upward due to thrips or downward due to mite feeding resulting in damage called chilli leaf curl or "murda" disease. In addition *S. dorsalis* is also reported to be a vector of the tomato spotted wilt tospovirus (Amin *et al*., 1981) [2]. The yield loss due to these two pests is estimated to the tune of 50 per cent (Kandaswamy *et al*., 1990, Desai *et al*., 2007) [10, 8]. The yield loss due to chilli mite may go up to 96.39 per cent (Borah, 1987) [5]leading sometimes to complete failure of crop itself (Kulkarni, 1922) [12]. Application of chemical pesticides has aggravated the problem of resurgence of chilli mite (David, 1991) [7]. Although, work on evaluation of chilli genotypes against thrips, *S. dorsalis* and mite, *Polyphagotarsonemus latus* has been reported by several workers (Kaur *et al.*, 2010, Singh and Singh 2009, Roopa, 2013) [11, 24, 19], screening accessions against both thrips and mites is meagre. Hence, the present study was carried out to identify promising genotypes having resistance to thrips and mites. To control these pests, frequent application of excessive and indiscriminate use of several insecticides causes heavy environmental pollution and health hazards along with pest resurgence problems which ultimately increases the cost of cultivation without giving satisfactory production. To overcome this menace, host plant resistance can play a key role in formulating alternative pest management strategies. Therefore, an alternative method by introducing or determining the use of resistant varieties that may contain different chemical substances to detoxify these insect's attack will be one of main component to be added in IPM as an environmental friendly pest management approaches.

2. Material and Methods

Evaluation of thirty one chilli genotypes was carried out for thrips and mite resistance under field condition during March 2015 at Karkipete, Chikamagalur district, Karnataka. Seedlings of all chilli genotypes were raised in nursery beds and 35 days old seedlings were transplanted to the experimental plot size of 4m row length. The experiment was laid out in a completely randomised block design replicated twice with the spacing of 60 x 30 cm. In the screening trail Byadgi Kaddi served as susceptible check. In the experimental plot, all the recommended package of practices was followed except plant protection measures *viz.*, insecticides and acaricides. Further, from each replication five chilli plants were selected randomly to record the insect and mite pest of chilli. Both adults and nymphs of thrips, *Scirtothrips dorsalis* (Hood) were counted from half to fully opened young top three leaves in five randomly selected and tagged plants were counted with the help of magnifying lens and later converted into per leaf. Whereas, mites *Polyphagotarsonemus latus* (Bank) were recorded (no's/leaf) on top, middle and bottom leaves on five selected and tagged plants were kept in the perforated polythene bag size 16×18 cm and were brought to laboratory and examined under 20 X magnification binocular microscope. The scoring was carried out according to the per cent damage caused by thrips and mites based on the genotype performance and all genotypes were categorized into five categories by adopting the Niles (1980) [14] method table 1. Various morphological and bio-chemical components of plants were studied at the crop maturity. Trichome density were recorded at 0.25 cm^2 area at the region near the veins and midrib on both abaxial and adaxial side of a fully developed leaf with the help of binocular microscope. Later it was expressed in cm^2 area. Green leaves of each genotype was selected from the top parts of the plant which are washed with distilled water, dried under shade and powdered for the estimation of biochemical components. Total phenol content of chilli leaves was estimated by folin-ciocalteu reagent (FCR) method described by Bray and Thorpe (1954) [6], whereas the estimation of chlorophyll content was carried out by SPAD 502 Plus®.

Table 1: Standard procedure for scoring Leaf Curl Index (LCI)

LCI/Grade (0-4)	Category	Symptoms
0.	Immune (I)	No symptom (No curling, completely healthy plant)
1.	Resistant (R)	1-25 per cent leaves/plant show curling, less damage
2.	Moderately Resistant (MR)	26-50 per cent leaves/ plant show curling, moderately damaged
3.	Susceptible (S)	51-75 per cent leaves/plant show curling, heavily damaged, malformation of growing points and reduction in plant height
4.	Highly Susceptible (HS)	> 76 per cent leaves/ plant show curling, severe and complete destruction of growing points, and drastic reduction in plant height, defoliation and severe malformation.

3. Results and Discussions

The results revealed that there was high variation in thrips and mite damage among different lines when recorded at every 15 days interval. The mean of thrips damage ranged from 0.60 to1.38 thrips/leaf. The less thrips population was found in DCC-3, 89 (0.60 thrips/leaf), DCC-87, 127, 27, 109, 24 (0.64 thrips/leaf), while the leaf curl index was ranged from 2.1 to 2.4 LCI/pl. were found better in comparison to susceptible check Byadgi Kaddi (1.38 thrips/leaf) which recorded highest damage to thrips incidence and leaf curl index is 4. The mean of mite damage ranged from 0.54 to1.14 mites/leaf. The less mite population was found in DCC-109, 221, 50, 89, 192, 55, 24 (0.54 mites/leaf), DCC-185 (0.58 mites/leaf), while the leaf curl index was ranged from 2.1 to 2.4 LCI/pl. were found better in comparison to susceptible check Byadgi Kaddi (1.14 mites/leaf) which recorded highest damage to mite incidence and leaf curl index is 4 (Table 2). Based on thrips and mite damage, the germplasm were categorised into resistant, moderately resistant, susceptible and highly susceptible by adopting the method of Niles (1980) [14] (Table 3). Among 31 chilli genotypes, no resistant genotypes were found whereas, four genotypes were recorded as moderately resistant, 11 susceptible and two were highly susceptible genotypes to both thrips and mites. The promising genotypes with moderately resistant reaction against thrips and mites includes DCC-3, 185, 109 and 89, whereas, DCC-66 and Byadgi Kaddi were found highly susceptible for both thrips and mite reaction. The moderately resistant genotypes showed avoidance factor against thrips and mite population as it has high trichome density (Table 4) and high chlorophyll and total phenol content (Table 5). The variation in damage may be due to differential load of thrips and mites population on different genotypes based on the morphological and biochemical variations in plants. The genotypes which are highly susceptible may be more preferred by the thrips and mites due to thin leaf, low chlorophyll and phenol content might have favoured more thrips population and thrips feeding damages the leaves, reducing the photosynthetic capacity, resulting in reduced fruit production (Shipp *et al.*, 1998) [23]. Other factors beyond the scope of the investigations might also be the key factors of resistance to thrips and mites. Any leaf character that interferes with the thrips life-cycle is a potential resistance factor which may contribute to the mechanism of defense against thrips and mites. It is known that both morphological and chemical characters of leaves can play a role in defense against insects (Rosenthal & Kotanen, 1994) [20].

3.1 Correlation studies: The results of correlation between morphological characters of plants and thrips (-0.768) and mites (-0.808) incidence revealed that thrips and mites population were found negatively correlated (Table 6&7) and similar results were obtained by Yadwad *et al.* (2008) [26].
Similarly, biochemicals in plants can also play a role of defense either directly or indirectly. Direct defense metabolites can be toxic or repellent, thereby affecting insect behavior and physiology (Roda and Baldwin, 2003) [21] while indirect defense can be triggered by releasing volatile compound to attract natural enemies of the insect pest. Even some of the biochemicals act as a feeding stimulant for sucking pests. The chemicals causing direct and indirect defense seem to be different. This is not always true for chemicals involved in antixenosis and antibiosis. In this study, some biochemicals like chlorophyll content and total phenols showed significantly negative association with the thrips and mite incidence.
The similar findings of negative association with chlorophyll and total phenol content was reported by Rameash *et al.* (2016) [17] reported that chlorophyll and total phenol content showed negative significant association with thrips incidence in chilli. Phenols have long been reported to provide resistance in plants during host plant interactions by several workers like Mondal *et al.* (2013) [13] and Subhash *et al.* (2013) [25] as it increases the unpalatability of the food materials which may be the possible reason for receiving low incidence of thrips. Simultaneously, higher total chlorophyll content resulted in dark colour may not attract thrips (Shaw *et al.*, 1991) [22]. It can be concluded that no single factor is responsible in thrips population fluctuation but all the factors work in compliment with each other for the development of resistance in plants against thrips reaction. So, these morphological and biochemical factors play a vital role in fluctuating the thrips population. Although, some knowledge on the mechanisms underlying thrips resistance are slightly understood. The effective and reliable screening procedures are also important in developing new resistant cultivars and this information provides guidelines for further selection of breeding strategies.

Table 2: Reaction of chilli genotypes against thrips (*S. dorsalis*) and mites (*P. latus*)

Sl. No.	Genotypes	Mean no. of thrips/leaf			Mean no. of mites/leaf		
		Average	**LCI/pl.**	**Resistance category***	**Average**	**LCI/pl.**	**Resistance category***
1.	DCC-3	0.60(1.27)	2.2	MR	0.56(1.25)	2.1	MR
2.	DCC-221	0.91(1.45)	3.1	S	0.54(1.23)	2.2	MR
3.	DCC-185	0.62(1.29)	2.4	MR	0.57(1.25)	2.3	MR
4.	DCC-187	0.64(1.30)	2.1	MR	0.83(1.41)	3.2	S
5.	DCC-177	0.90(1.45)	3.3	S	0.84(1.42)	3.4	S
6.	DCC-52	0.92(1.46)	3.1	S	1.13(1.56)	4	HS
7.	DCC-127	0.64(1.30)	2.2	MR	0.86(1.43)	3.2	S
8.	DCC-103	0.92(1.46)	3.3	S	0.84(1.42)	3.4	S
9.	DCC-27	0.64(1.30)	2.2	MR	0.84(1.42)	3.2	S
10.	DCC-20	1.46(1.71)	4	HS	0.82(1.41)	3.2	S
11.	DCC-39	0.97(1.48)	3.2	S	0.84(1.42)	3.2	S
12.	DCC-50	0.94(1.47)	3.4	S	0.54(1.23)	2.2	MR
13.	DCC-109	0.64(1.30)	2.4	MR	0.56(1.25)	2.2	MR
14.	DCC-89	0.60(1.27)	2.2	MR	0.54(1.23)	2.1	MR
15.	DCC-15	0.94(1.47)	3.2	S	0.90(1.45)	3.4	S
16.	DCC-184	0.92(1.46)	3.3	S	0.85(1.42)	3.2	S
17.	DCC-18	1.28(1.63)	4	HS	0.80(1.39)	3.3	S
18.	DCC-192	0.97(1.48)	3.4	S	0.54(1.23)	2.4	MR
19.	DCC-239	0.95(1.47)	3.2	S	0.82(1.41)	3.3	S
20.	DCC-157	1.30(1.64)	4	HS	0.85(1.42)	3.4	S
21.	DCC-44	0.97(1.48)	3.4	S	0.82(1.41)	3.3	S
22.	DCC-24	0.64(1.30)	2.1	MR	0.54(1.23)	2.2	MR
23.	DCC-48	0.92(1.46)	3.1	S	0.85(1.42)	3.4	S
24.	DCC-55	0.62(1.29)	2.2	MR	0.54(1.23)	2.1	MR
25.	DCC-92	1.30(1.64)	4	HS	0.84(1.42)	3.3	S
26.	DCC-167	0.91(1.45)	3.2	S	0.85(1.42)	3.4	S
27.	DCC-56	0.99(1.49)	3.3	S	1.13(1.56)	4	HS
28.	DCC-230	0.91(1.45)	3.2	S	0.80(1.39)	3.3	S
29.	DCC-43	0.96(1.48)	3.2	S	0.77(1.38)	3.3	S
30.	DCC-66	1.33(1.66)	4	HS	1.13(1.56)	4	HS
31.	Byadgi Kaddi	1.38(1.67)	4	HS	1.14(1.57)	4	HS
S Em ±			0.02	-	-		0.02
C D 5%			0.06	-	-		0.07

DCC- Devihosur Chilli Collection; DAT - Days After Transplanting; LCI= Leaf Curl Index;
Values in parenthesis are square root +0.5 transformed.
* = Resistance category; R = Resistant; MR = Moderately resistant; S=Susceptible; HS=Highly Susceptible

Table 3: Categorization of chilli genotypes based on thrips and mite infestation

Sl. No.	Categories	Reaction of chilli genotypes to	
		S. dorsalis	*P. latus*
1	Immune (I)	Nil	Nil
2	Resistant (R)	Nil	Nil
3	Moderately Resistant (MR)	DCC-3, DCC-185, DCC-187, DCC-127, DCC-27, DCC-109, DCC-89, DCC-24, DCC-55	DCC-3, DCC-221, DCC-185, DCC-50, DCC-109, DCC-89, DCC-192, DCC-24, DCC-55
4	Susceptible (S)	DCC-221, DCC-177, DCC-52, DCC-103, DCC-39, DCC-50, DCC-15, DCC-184, DCC-192, DCC-239, DCC-44, DCC-48, DCC-167, DCC-56, DCC-230, DCC-43	DCC-187, DCC-177, DCC-127, DCC-103, DCC-27, DCC-20, DCC-39, DCC-15, DCC-184, DCC-18, DCC-239, DCC-157, DCC-44, DCC-48, DCC-92, DCC-167, DCC-230, DCC-43
5	Highly Susceptible (HS)	DCC-20, DCC-18, DCC-157, DCC-92, DCC-66, Byadgi Kaddi	DCC-52, DCC-56, DCC-66, Byadgi Kaddi

Table 4: Morphological characters of chilli genotypes

Sl. No.	Genotypes	Trichome density (cm^2)			Colour of the leaves	Leaf thickness
		Abaxial Surface	Adaxial Surface	Average		
1.	DCC-3	74.20	80.25	77.23	Dark green	Thick
2.	DCC-221	50.45	27.20	38.82	Light green	Thin
3.	DCC-185	48.32	74.22	61.27	Dark green	Thick
4.	DCC-187	60.25	38.30	49.28	Dark green	Thick
5.	DCC-177	30.05	34.45	32.25	Light green	Thin
6.	DCC-52	24.18	36.50	30.34	Light green	Thin
7.	DCC-127	70.30	28.62	49.46	Dark green	Thick
8.	DCC-103	34.20	22.30	28.25	Light green	Thin
9.	DCC-27	36.40	76.20	56.30	Dark green	Thick
10.	DCC-20	26.30	50.25	38.28	Light green	Thin
11.	DCC-39	12.32	24.40	18.36	Light green	Very thin
12.	DCC-50	22.25	70.22	46.24	Light green	Thin
13.	DCC-109	48.36	66.25	57.32	Dark green	Thick
14.	DCC-89	64.40	64.30	64.35	Dark green	Thick
15.	DCC-15	20.32	28.25	24.31	Light green	Thin
16.	DCC-184	28.42	50.20	39.00	Light green	Thin
17.	DCC-18	04.00	27.42	15.71	Light green	Very thin
18.	DCC-192	16.50	60.25	38.38	Light green	Thin
19.	DCC-239	32.48	28.20	30.34	Light green	Thin
20.	DCC-157	06.52	34.15	20.34	Light green	Very thin
21.	DCC-44	32.60	36.30	34.45	Light green	Thin
22.	DCC-24	48.58	70.42	59.50	Dark green	Thick
23.	DCC-48	30.55	34.35	32.45	Light green	Thin
24.	DCC-55	60.25	74.15	67.20	Dark green	Thick
25.	DCC-92	38.42	44.30	41.36	Light green	Very thin
26.	DCC-167	34.20	38.20	36.20	Light green	Thin
27.	DCC-56	36.15	30.20	33.18	Light green	Thin
28.	DCC-230	34.00	38.50	36.25	Light green	Thin
29.	DCC-43	26.35	36.15	31.25	Light green	Thin
30.	DCC-66	12.30	08.20	10.25	Light green	Very thin
31.	Byadgi Kaddi	14.25	38.00	26.12	Light green	Very thin

DCC – Devihosur Chilli Collection

Table 5: Estimation of chlorophyll and total phenol content in chilli genotypes

Sl. No.	Genotypes	Chlorophyll (Spad readings)	Total phenol (mg/g)	Sl. No.	Genotypes	Chlorophyll (Spad readings)	Total phenol (mg/g)
1.	DCC-3	84.40	12.80	18.	DCC-192	65.50	10.64
2.	DCC-221	65.60	9.95	19.	DCC-239	63.80	9.98
3.	DCC-185	81.70	12.08	20.	DCC-157	51.60	7.62
4.	DCC-187	76.70	12.50	21.	DCC-44	65.60	9.50
5.	DCC-177	63.80	10.66	22.	DCC-24	73.60	12.20
6.	DCC-52	65.50	10.63	23.	DCC-48	63.20	9.82
7.	DCC-127	77.20	11.85	24.	DCC-55	77.20	12.26
8.	DCC-103	63.30	10.66	25.	DCC-92	54.80	7.36
9.	DCC-27	72.60	11.50	26.	DCC-167	65.60	9.52
10.	DCC-20	54.80	7.36	27.	DCC-56	60.90	10.68
11.	DCC-39	60.90	9.50	28.	DCC-230	61.80	9.68
12.	DCC-50	61.80	10.66	29.	DCC-43	66.10	9.26
13.	DCC-109	82.10	11.80	30.	DCC-66	58.60	7.60
14.	DCC-89	71.40	12.20	31.	Byadgi Kaddi	49.20	9.52

15.	DCC-15	66.10	9.20	S Em ±	0.37	0.05
16.	DCC-184	61.80	9.45	C D 5%	1.08	0.15
17.	DCC-18	49.20	8.27			

Table 6: Correlation of *Scirtothrips dorsalis* population with trichome density, chlorophyll and total phenol content of chilli genotypes

Parameters	Y	X_1	X_2	X_3
Y= Thrips Population	1.00	-0.768**	-0.919**	-0.956**
X_1= Trichome density		1.00	-0.799**	-0.760**
X_2= Total chlorophyll			1.00	-0.881**
X_3= Total phenols				1.00

Table 7: Correlation of *Polyphgotarsonemus latus* population with trichome density, chlorophyll and total phenol content of chilli genotypes

Parameters	Y	X_1	X_2	X_3
Y= Mite Population	1.00	-0.808**	-0.492**	-0.491**
X_1= Trichome density		1.00	-0.799**	-0.760**
X_2= Total chlorophyll			1.00	-0.881**
X_3= Total phenols				1.00

4. Conclusion
The present investigation was undertaken screening of chilli varieties against thrips and mites, none of them was found completely free from the attack of pests. The genotypes, DCC-3, 185, 109 and 89 were observed as moderately resistant, while DCC-66 and Byadgi Kaddi were found highly susceptible to both thrips and mite. The morphological and biochemical characters *viz*., trichome density, chlorophyll and phenol content were significantly negatively correlated with the population of thrips, mites and LCI. The maximum fruit yield of chilli was also obtained in the DCC-109, 185, 3 followed by DCC-89.

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