Biological Forum – An International Journal **14(2): 1520-1526(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Impact of certain Biochemicals on the Expression of Resistance in certain Chilli Germplasm to Chilli Thrips, *Scirtothrips dorsalis* Hood

S. Leela Praveen[1*], L.N. Mohapatra[1], P. Naresh[2] and G.S. Sahu[3]
[1]College of Agriculture, Department of Entomology,
Odisha University of Agriculture and Technology, Bhubaneswar (Odisha), India.
[2]Division of Vegetable Crops, ICAR-Indian institute of Horticulture Research, Bengaluru (Karnataka) India.
[3]College of Agriculture, Department of Vegetable crops,
Odisha University of Agriculture and Technology, Bhubaneswar (Odisha), India.

(Corresponding author: S. Leela Praveen)*
(Received 28 April 2022, Accepted 18 June, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The biochemical factors *viz.*, low proline, protein, total sugars and reducing sugar content and high contents of phenol, non-reducing sugar and total chlorophyll in the leaves contributed to imparting resistance in chilli germplasm to chilli thrips, *Scirtothrips dorsalis* Hood. The resistant germplasm *viz.*, BC-7-2-1, BC-25 and moderately resistant germplam *viz.*, BC-27-2-2, BC-21, BC-79-1, Utkal Abha and BC-406 had 3.76-6.33 µ moles/ gram of proline,13.56-15.96 mg/ gram protein, 3.59-3.99 per cent total sugar, 1.01-1.54 per cent reducing sugar, 2.96-4.12 mg/ gram phenol, 2.45-2.58 per cent non-reducing sugar and 13.68 - 16.44 mg/ gram total chlorophyll in leaf sample, respectively as against 7.3-8.92 µ moles/ gram, 16.32-18.54 mg/ gram, 4.32-4.59 per cent, 1.93-2.28 per cent, 1.46-2.38 mg/ gram, 2.31-2.39 per cent and 9.96-12.47 mg/ gram in the leaves of susceptible and highly susceptible check chilli germplasm, respectively. A significantly inverse relation existed between the phenol (-0.975), non-reducing sugar (-0.985) and total chlorophyll (-0.990) and the incidence of *S. dorsalis.* The multiple linear regression analysis revealed that all these biochemical factors together influenced the population of *S. dorsalis* to an extent of 97.32 per cent.

Keywords: Resistance, chiili germplasm, thrips, *S. dorsalis*, Biochemicals.

INTRODUCTION

Among the arthropod pests, chilli thrips, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae) is known to pose serious threat to chilli cultivation and is primarily responsible for low productivity in India. Fruit yield loss due to this dreaded pest in India is estimated to be to the tune of 50-90 per cent (Kandasamy *et al.* 1990). Frequency of insecticide application have increased over the years in chilli ecosystem for managing *S. dorsalis* as result of which the cost of cultivation has increased enormously and making cultivation of chilli highly risky. In addition to this, pesticidal sprays became a threat to chilli ecosystem causing problems of resistance, resurgence of pests, pesticidal residues and menace to natural enemies fauna (David 1986; Awasthi *et al.,* 2011). Host plant resistance having compatibility with all other methods of pest control without causing any adverse effect in chilli ecosystem has been considered as an important IPM component. Identification of resistant/tolerant chilli germplasm is the most vital option to manage this dreaded pest for which knowledge on morphological and biochemical bases of resistance is highly essential. Several biochemicals in crop plants are known to provide resistance to insect pests. In the present investigation an attempt has been made to study the biochemical components in the leaves of the some chilli germplasms and their relation with thrips incidence so as to identify the source of resistance for use in breeding programme.

MATERIALS AND METHODS

Twelve chilli germplasms *viz*., BC-25, BC-79-1, BC-27-2-2, Utkal Abha, BC-21, BC-406, BC-28, LCA-620, BC-78-1-2, BC-24-1 along with resistant check BC-7-2-1 and susceptible check Byadagi kaddi were evaluated under pot culture experiment in Department of Entomology, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha during 2019-20 under insect free conditions. The experiment was laid out in randomized block design with three replications. The chilli germplasms were raised in pot tray and transplanted at six weeks after germination. Three plants per genotype were planted in 10 x 12 inches poly bag. Plants were spaced 60 cm between rows and 45 cm between plants in a row. Agronomic practices recommended for the pot culture crop were followed. Observations on population of nymphs and adults of *S. dorsalis* were recorded on three leaves of chilli at top, middle and bottom canopy from three plants at weekly interval from the appearance of the pest to last picking of the chilli fruits. The population was counted visually by using a magnifying lens in early morning hours (Bhede *et al*., 2008). For studies on biochemical bases of resistance in selected chilli germplasm to *S. dorsalis*, leaf samples from pot culture experiment at 60 DAT coinciding with the peak activity period of *S. dorsalis* were used. Standard procedures as suggested by various researchers followed for estimating the biochemicals viz., proline content (Bates *et al*., 1973), phenol content (Malick and Singh 1980), protein content (Lowry *et al*., 1951), total soluble sugar (Hedge and Hofreieter 1962), reducing sugar (Somogyi, 1952), non-reducing sugar content (Somogyi, 1952) and chlorophyll content (Arnon, 1949). Each sample was replicated thrice and the data on all these biochemical factors of leaf samples were subjected to statistical analysis. The chemical constituents of leaf samples of various test chilli germplasm were correlated with the population of *S. dorsalis.*

RESULTS AND DISCUSSION

Results of analysis of mean pool data of 14DAT, 21 DAT, 28 DAT, 35 DAT, 42 DAT, 56 DAT, 63 DAT, 70 DAT, 77 DAT, 84 DAT, 91 DAT and 98 DAT on population of *S. dorsalis* in different chilli germplasm revealed significantly lowest mean population of *S. dorsalis* in the resistant germplasm BC-7-2-1(resistant check) (0.70) which was at par with other resistant germplasm BC-25 (0.72). Lower population of *S. dorsalis* ranging from 1.18 to 1.31 per leaf was observed in the five moderately resistant germplasm *viz.,* BC-27-2-2 (1.18), BC-21 (1.22), BC-79-1 (1.25), Utkal Abha (1.29) and BC-406 (1.31). The susceptible check Byadagi kaddi recorded the highest population of *S. dorsalis* (2.46/leaf) which was at par with the other susceptible germplasm BC-24-1 (2.38/leaf). The population of *S. dorsalis* ranged from 1.86/leaf (BC-28) to 1.93/leaf (BC-78-1-2) in rest of the susceptible germplasm (Table 1).

Table 1: Reaction of selected chilli germplasm to the attack of *S. dorsalis* under pot culture experiment at Bhubaneswar during 2019-20 (based on its population).

Sr.No	Germplasm	Mean population of *S. dorsalis* (Nos./leaf) at different growth stages												
		14 DAT	21 DAT	28 DAT	35 DAT	42 DAT	49 DAT	56 DAT	63 DAT	70 DAT	77 DAT	84 DAT	91 DAT	Mean
1	**BC-25**	0.09 (0.30)	0.36 (0.60)	0.66 (0.81)	0.77 (0.88)	0.93 (0.97)	0.79 (0.89)	0.83 (0.91)	0.66 (0.81)	0.66 (0.81)	0.70 (0.84)	0.73 (0.85)	0.72 (0.85)	0.72 (0.85)
2	**BC-27-2-2**	0.12 (0.35)	0.63 (0.79)	0.89 (0.94)	1.20 (1.09)	1.49 (1.22)	2.84 (1.69)	2.85 (1.69)	1.41 (1.19)	1.09 (1.05)	0.93 (0.97)	0.90 (0.95)	0.90 (0.95)	1.18 (1.09)
3	**BC-21**	0.13 (0.37)	0.64 (0.80)	0.90 (0.95)	1.37 (1.17)	1.49 (1.22)	3.20 (1.79)	2.88 (1.70)	1.43 (1.19)	1.11 (1.06)	0.95 (0.98)	0.94 (0.97)	0.89 (0.94)	1.22 (1.11)
4	**BC-79-1**	0.13 (0.37)	0.70 (0.84)	0.92 (0.96)	1.33 (1.15)	1.61 (1.27)	3.44 (1.85)	2.86 (1.69)	1.60 (1.27)	1.09 (1.04)	0.91 (0.95)	0.91 (0.95)	0.88 (0.94)	1.25 (1.12)
5	**Utkal Abha**	0.23 (0.48)	0.68 (0.82)	1.15 (1.07)	1.37 (1.17)	1.70 (1.30)	3.41 (1.85)	2.72 (1.65)	1.79 (1.34)	1.25 (1.12)	0.88 (0.94)	0.95 (0.97)	0.88 (0.94)	1.29 (1.14)
6	**BC-406**	0.24 (0.49)	0.69 (0.83)	1.03 (1.02)	1.35 (1.16)	1.80 (1.34)	3.39 (1.84)	2.63 (1.62)	1.59 (1.26)	1.39 (1.18)	1.19 (1.09)	1.06 (1.03)	0.93 (0.96)	1.31 (1.15)
7	**BC-28**	0.49 (0.70)	0.80 (0.90)	1.51 (1.23)	2.51 (1.58)	2.78 (1.67)	4.57 (2.14)	4.14 (2.03)	3.27 (1.81)	2.29 (1.51)	1.43 (1.20)	1.61 (1.27)	1.39 (1.18)	1.86 (1.36)
8	**LCA-620**	0.33 (0.58)	0.88 (0.94)	1.59 (1.26)	2.59 (1.61)	3.10 (1.76)	4.61 (2.15)	4.11 (2.03)	3.29 (1.81)	2.51 (1.58)	1.59 (1.26)	1.63 (1.28)	1.22 (1.10)	1.90 (1.38)
9	**BC-78-1-2**	0.39 (0.62)	0.81 (0.90)	1.68 (1.30)	2.68 (1.64)	3.44 (1.85)	4.41 (2.10)	4.15 (2.04)	3.40 (1.84)	2.62 (1.62)	1.61 (1.27)	1.65 (1.28)	1.19 (1.09)	1.93 (1.39)
10	**BC-24-1**	0.56 (0.75)	1.46 (1.21)	2.24 (1.50)	3.24 (1.80)	4.28 (2.07)	5.19 (2.28)	4.95 (2.23)	4.47 (2.11)	3.03 (1.74)	2.65 (1.63)	2.29 (1.51)	1.64 (1.28)	2.38 (1.54)
11	**BC-7-2-1(RC)**	0.07 (0.26)	0.30 (0.54)	0.70 (0.83)	0.74 (0.86)	0.81 (0.90)	0.70 (0.84)	0.78 (0.88)	0.74 (0.86)	0.70 (0.83)	0.68 (0.82)	0.70 (0.84)	0.69 (0.83)	0.70 (0.84)
12	**Byadagi kaddi (sc)**	0.82 (0.91)	1.50 (1.22)	2.47 (1.57)	3.31 (1.82)	4.37 (2.09)	5.39 (2.32)	4.89 (2.21)	4.75 (2.18)	3.10 (1.76)	2.78 (1.67)	2.29 (1.51)	1.63 (1.28)	2.46 (1.57)
	Mean	**0.30**	**0.79**	**1.31**	**1.87**	**2.32**	**3.50**	**3.15**	**2.37**	**1.74**	**1.36**	**1.31**	**1.08**	**1.51**
	SE(m)±	**0.100**	**0.066**	**0.136**	**0.111**	**0.106**	**0.118**	**0.114**	**0.100**	**0.137**	**0.077**	**0.087**	**0.070**	**0.102**
	C.D (5%)	**0.29**	**0.19**	**0.39**	**0.32**	**0.31**	**0.35**	**0.33**	**0.29**	**0.40**	**0.23**	**0.25**	**0.20**	**0.30**

Figures in parentheses are square root transformed values.

The results of the study on biochemical compositions of leaves of twelve selected chilli germplasm revealed significant difference in proline, phenol, protein, total sugars, reducing sugars, non-reducing sugars and chlorophyll content amongst them (Table 2).

Proline: The proline content in the leaves of twelve test chilli germplasm ranged between 3.76 µ moles/ gram and 8.92 µ moles/ gram (Table 2). The resistant check germplasm BC-7-2-1 had lowest proline content of 3.76 µ moles/ gram which was closely followed by the other resistant chilli germplasm BC-25 (3.89 µ moles/ gram). The moderately resistant germplasm *viz*., BC-27-2-2, BC-21, BC-79-1, Utkal Abha and BC-406 had comparatively low proline content of 4.47, 4.82, 5.33, 6.09 and 6.33 µ moles/ gram, respectively than the susceptible and highly susceptible germplasm where the proline content ranged between 7.3 and 8.92 µ moles/ gram. Highest proline content was recorded in the susceptible check Byadagi kaddi (8.92 µ moles/ gram) followed by the other susceptible germplasm BC-24-1 (8.55 µ moles/ gram).

Proline, an amino acid has been shown to accumulate in many plants in response to abiotic and biotic stresses, where it plays a protective role including antioxidant function, protein protection and synthesis (as chaperone) and as a signalling molecule (Szabados and Savoure 2009). It is known to participate in a number of physiological functions in insects. Herbivory of plants generally stimulates accumulation of proline whereas total carbohydrate content decreases and content of phenolics remains unaffected (Khattab, 2007). The excessive synthesis of proline may have resulted in the cytosol at the expense of protein and resulted into the accumulation of excessive proline in the tissues as defensive arsenal in proportion to severity of herbivores. Diet selection based on the level of proline in an insect's host plant has been observed for a number of phytophagous insects. Information on relationship of proline content with the incidence of *S. dorsalis* in chilli is meagre in published literature. Khattab and Khattab (2005) reported that proline concentration in insect infested eucalyptus leaves was higher. Herbivory caused by grasshopper, *Choreodocus illustris* resulted more damaged leaves which reduced the plant growth due to loss of chlorophyll content and led to proline accumulation at the cost of protein (Rehman *et al*., 2016). According to Nasrin *et al.* (2021), the susceptible chilli variety BINA Morich 2 had highest proline activity in the leaves as compared to less proline content in the leaves of moderately resistant variety BARI Morich 2. Thus, the present observations confirmed the findings of these authors. Evidence in support of the significantly positive correlation between the incidence of *S. dorsalis* in chilli and the proline activity was also reported by Nasrin *et al.* (2021).

Phenol: The phenol content of leaf samples of the twelve selected test germplasm varied from 1.46 mg g^{-1} to 4.12 mg g^{-1}, the lowest being in susceptible check germplasm Byadagi kaddi and highest in the resistant check germplasm BC-7-2-1 (Table 2). The phenol content was higher (2.96 mg g^{-1} to 4.12 mg g^{-1}) in the leaves of germplasm *viz*., BC-7-2-1 (resistant check) (4.12mg g^{-1}), BC-25 (3.86 mg g^{-1}), BC-27-2-2 (3.74 mg g^{-1}), BC-21 (3.67 mg g^{-1}), BC-79-1 (3.58 mg g^{-1}), Utkal Abha (3.28 mg g^{-1}) and BC-406 (2.96mg g^{-1}) showing moderate resistance reaction to *S. dorsalis* as compared to the highly susceptible and susceptible germplasm *viz*., Byadagi kaddi (susceptible check), BC-24-1, BC-78-1-2, LCA-620 and BC-28 where it ranged from 1.46 to 2.38 mg g^{-1}.

Phenolics are the aromatic benzene ring compounds with one or more hydroxyl groups produced in the plant for protection against biotic stresses (Showket *et al.*, 2017). These compounds are associated with the resistant traits of several crop plants (Link and Walker, 1933). The enhancement in the phenol contents in response to insect infestation is considered to be a general phenomenon as it reduces the growth and development of herbivores (Ramiro *et al*., 2006 and War *et al*., 2012). Phenolic compounds induced in the plants are either directly toxic to insects or mediate the signaling of various transduction pathways, which in turn produce toxic secondary metabolites and activate various defensive enzymes (Helmi and Mohamed 2016). Higher level of phenols in several resistant/moderately resistant crops leads to low incidence of thrips possibly due to unpalatability of the food materials. Low incidence of *S. dorsalis* in chilli due to higher phenol content in the leaves was earlier reported by Mondal *et al*. (2013); Rameash *et al.* (2015); Rameash *et al*. (2017); Latha and Hunumanthraya (2018); Chaudhary and Pandya (2019). The findings on significantly negative correlation between phenol content in the chilli leaves and the incidence of *S. dorsalis* are in conformity with the results reported by Roopa (2013); Megharaj *et al.* (2016); Latha and Hunumanthraya (2018).

Table 2: Biochemical composition of leaves of some selected chilli germplasm (2019-20).

Sl.No	Germplasm	Proline (µ moles/ g)	Phenol (mg/g)	Protein (mg/g)	Total sugar (%)	Reducing sugar (%)	Non reducing sugar (%)	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total chlorophyll (mg/g)
1	BC-25	3.89	3.89	13.96	3.62	1.06	2.56	5.65	10.13	15.79
2	BC-27-2-2	4.47	3.74	14.22	3.85	1.33	2.52	5.01	9.30	14.31
3	BC-21	4.82	3.67	14.39	3.90	1.42	2.48	4.96	9.33	14.29
4	BC-79-1	5.33	3.58	14.94	3.92	1.45	2.47	4.77	9.42	14.19
5	Utkal Abha	6.09	3.28	15.36	3.98	1.52	2.46	4.89	9.27	14.15
6	BC-406	6.33	2.96	15.96	3.99	1.54	2.45	4.56	9.12	13.68
7	BC-28	7.30	2.38	16.32	4.32	1.93	2.39	4.21	8.26	12.47
8	LCA-620	7.84	2.24	16.88	4.40	2.03	2.37	4.12	8.12	12.24
9	BC-78-1-2	8.52	2.00	17.86	4.46	2.11	2.35	3.87	7.48	11.36
10	BC-24-1	8.55	1.56	18.18	4.57	2.27	2.30	3.66	6.97	10.63
11	BC-7-2-1(RC)	3.76	4.12	13.56	3.59	1.01	2.58	5.87	10.57	16.44
12	Byadagi kaddi (SC)	8.92	1.46	18.54	4.59	2.28	2.31	3.43	6.52	9.96
	SE(m)±	**0.021**	**0.067**	**0.024**	**0.003**	**0.003**	**0.0058**	**0.0075**	**0.0087**	**0.0083**
	CD (5%)	**0.061**	**0.197**	**0.069**	**0.0096**	**0.0097**	**0.0169**	**0.0218**	**0.0253**	**0.0242**

Protein: The protein content in the leaves of tested chilli germplasm ranged between 13.56 mg g^{-1} (BC-7-2-1) (resistant check) and 18.54 mg g^{-1} (Byadagi kaddi) (susceptible check) (Table 2). The protein content was comparatively low (13.56 mg $g^{-1}$to 15.96 mg g^{-1}) in the leaves of resistant and moderately resistant germplasm *viz.*,BC-7-2-1 (13.56 mg g^{-1}), BC-25 (13.96 mg g^{-1}), BC-27-2-2 (14.22 mg g^{-1}), BC-21 (14.39 mg g^{-1}), BC-79-1 (14.94 mg g^{-1}), Utkal Abha (15.36 mg g^{-1}) and BC-406 (15.96 mg g^{-1}). The germplasm *viz.,* BC-28, LCA-620, BC-78-1-2, BC-24-1 and Byadagi kaddi (susceptible check) having higher infestation of *S. dorsalis* were with higher protein content of (16.32 mg g^{-1}to18.54 mg g^{-1}).

Proteins are the central biomolecules that are responsible for all cellular functions in the living organism. Modifications in plant protein profiles are the first response of plants to insect herbivory. Such qualitative and quantitative changes in proteins play an important role in signal transduction and oxidative defense of plants (Green and Ryan 1972; Rafi *et al.*, 1996; Ni *et al.,* 2001). Information on change in total protein content in the leaves of chilli due to attack of *S. dorsalis* is scarce in published literature. The present results are comparable with Chen *et al*. (2009) who stated that an increase in protein content is a general phenomenon in plants in response to insect damage as defence mechanism. Chilli cultivars with higher quantity of total proteins enhanced susceptibility to thrips damage (Alabi *et al.*, 2005). Roopa (2013) reported higher content of total proteins in the susceptible chilli genotypes to *S. dorsalis* as compared to the moderately resistant genotypes. According to Chaudhary and Pandya (2019), the chilli variety GVC-111 harbouring a moderately population of *S. dorsalis* had minimum protein content in the leaves as compared to maximum protein content in the leaves of a susceptible chilli genotypes GCH-3. All these findings of previous workers are in full agreement with the results of the present investigation. The positive relationship as found in the present study between the total protein content of leaves and infestation of *S. dorsalis* corroborates with the findings of Roopa (2013); Chaudhary and Pandya (2019).

Total sugar: The total sugar content in the leaves of twelve test chilli germplasm varied from 3.59 per cent to 4.59 per cent (Table 2). The resistant check germplasm BC-7-2-1 had lowest total sugar content of 3.59 per cent which was closely followed by the other resistant chilli germplasm BC-25 (3.62 per cent). The moderately resistant germplasm *viz*., BC-27-2-2, BC-21, BC-79-1, Utkal Abha and BC-406 had comparatively low total sugar content of 3.85, 3.90, 3.92, 3.98 and 3.99 per cent respectively, than the susceptible and highly susceptible germplasm where the total sugar content ranged between 4.32 and 4.59 per cent. Highest total sugar content was recorded in the susceptible check Byadagi kaddi (4.59 per cent) which was closely followed by the highly susceptible germplasm BC-24-1 (4.57 per cent).

Sugars, the dominant soluble leaf carbohydrates of plants are the substrates in respiratory reactions or intermediate metabolites in many other biochemical processes. They have protective role against stress factors, for example, as osmoprotectants, donors of carbon skeletons or signaling molecules (Ciereszko 2009; Morkunas and Ratajczak 2014). These compounds are also involved in the synthesis of phenolic compounds, lectins, etc. as defence mechanism. The role of plant sugar contents in the resistance of various crops to sucking pest was earlier reported by Mittler (1967), Corcuera (1993) and Nawalgatti *et al.* (1993). The observations in respect of lower total sugar content in the leaves of resistant and moderately resistant chilli germplasm are in full conformity with the findings of Roopa (2013); Subhash *et al.* (2013); Chaudhary and Pandya (2019). Several earlier researchers also observed significant positive correlation between the incidence of *S. dorsalis* and the total sugar content in the leaves of chilli germplasm (Roopa, 2013; Subhash *et al.*, 2013).

Reducing sugar: The reducing sugar content in the leaves of twelve test chilli germplasm ranged between 1.01 per cent and 2.28 per cent (Table 2). Lowest reducing sugar content of 1.01 per cent was observed in the resistant check germplasm BC-7-2-1 which was closely followed by the other resistant chilli germplasm BC-25 (1.06 per cent). A lower range of reducing sugar content (1.33 to 1.54 per cent) was recorded in the moderately resistant germplasm *viz*., BC-27-2-2, BC-21, BC-79-1, Utkal Abha and BC-406 as compared to the susceptible and highly susceptible germplasm where the reducing sugar content ranged between 2.03 and 2.28 per cent. Highest reducing sugar content was recorded in the susceptible check Byadagi kaddi (2.28 per cent) which was closely followed by the highly susceptible germplasm BC-24-1 (2.27 per cent).

Reducing sugars are the disaccharides, oligosaccharides, polysaccharides and all monosaccharides in the host plant which influence positively the feeding of insect pests. These are the essential component in insect nutrition. The more reducing sugars resulted in more sweetness of leaves which act as a feeding stimulant for sucking pests. Genotypes containing higher total sugars with high reducing sugars exhibited susceptibility towards thrips incidence. Lower amount of reducing sugar in the leaves of chilli genotypes resistant/moderately resistant to *S. dorsalis* was observed by several earlier researchers (Varadharajan and Veeravel 1996; Megharaj *et al.*, 2016; Chaudhary and Pandya 2019). The present observations are in close akin with the findings of the above workers and that of Subhash *et al.* (2013) who have also reported positive relationship between reducing sugar content in the leaves and the incidence of *S. dorsalis*.

Non- reducing sugar: The non- reducing sugar content of leaf samples of the selected test germplasm varied from 2.30 per cent to 2.58 per cent, the lowest being in highly susceptible germplasm BC-24-1 and highest in the resistant check germplasm BC-7-2-1 (Table 2). The leaves of germplasm *viz*., BC-7-2-1, BC-25, BC-27-2-2, BC-21, BC-79-1, Utkal Abha and BC-406 showing resistance reaction to *S. dorsalis* had comparatively higher non- reducing sugar content (2.45 to 2.58 per cent) as compared to the susceptible and highly susceptible germplasm *viz*., BC-24-1, Byadagi kaddi (SC), BC-78-1-2, LCA-620 and BC-28 where it ranged from 2.30 to 2.39 per cent.

Non reducing sugars are the polysaccharides in plant and the most common example of non-reducing sugar is sucrose. Sucrose is the major product of photosynthesis and contributes to various regulatory mechanisms in plants including growth and development, differential gene expression and stress-related responses (Wind *et al*., 2010). Involvement of non reducing sugars having more insects feeding on plants has been reported in different plant insect interaction studies (Athar *et al*., 2011). Information on relationship of non reducing content in the leaves with the incidence of *S. dorsalis* in chilli is rather scarce in published literature except the report of Megharaj *et al.* (2016); Chaudhary and Pandya (2019) who recorded lower reducing sugar content in chilli germplasm harbouring moderate population of *S. dorsalis*. The negative relationship as found in the present study between the non reducing sugar content of leaves and infestation of *S. dorsalis* is in accordance with the findings of Megharaj *et al.* (2016); Chaudhary and Pandya (2019).

Total chlorophyll content: The total chlorophyll content (sum of chlorophyll-a and chlorophyll-b) in the leaves of twelve test chilli germplasm varied from 9.96

mg g $^{-1}$ to 16.44 mg g $^{-1}$ (Table 2). The resistant check germplasm BC-7-2-1 had highest total chlorophyll content of 16.44 mg g^{-1} which was closely followed by the other resistant germplasm BC-25 (15.79 mg g^{-1}). The moderately resistant germplasm *viz.,* BC-27-2-2, BC-21, BC-79-1, Utkal Abha and BC-406 had comparatively higher total chlorophyll content of 14.31, 14.29, 14.19, 14.15 and 13.68 mg g^{-1} respectively, than susceptible and highly susceptible germplasm where total chlorophyll content ranged between 9.96 mg g^{-1} and 12.47 mg g^{-1}. Lowest total chlorophyll content was recorded in the susceptible check Byadagi kaddi (9.96 mg g^{-1}) which was closely followed by the highly susceptible germplasm BC-24-1 (10.63 mg g^{-1}).

Photosynthetic pigment *viz.*, leaf chlorophyll content and carotenoids in plant tissue are the key parameters in the photosynthetic productivity which gets altered during defensive responses against the attacking insect pest (Gomez *et al*., 2004; Mao *et al*., 2007). Helmi and Rashwann (2015) reported that photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoids) showed negative relationship with sap sucking insects. The present observations on higher amount of chlorophyll content in the resistant and moderately resistant chilli germplasm corroborates with the report of Megharaj *et al.* (2016); Latha and Hanumantharay (2018); Chaudhary and Pandya (2019); Nasrin *et al.* (2021). The decrease in the photosynthetic pigment in the susceptible chilli germplasm might be ascribed to the inhibition of pigment biosynthesis which results from the alteration in mineral nutrition or lack of assimilates (Stacey and Keen 1996). Significantly negative relationship between total chlorophyll content of chilli leaves and the incidence of *S. dorsalis* was also reported earlier by Rameash *et al*. (2015); Megharaj *et al.* (2016); Latha and Hanumantharay (2018); Nasrin *et al.* (2021). The reason for negative association in the present study might be attributed to the reduction of leaf size and leaf curl owing to thrips infestation and consequent decline in the photosynthetic activity and chlorophyll content of leaves.

Results on correlation studies between population of *S. dorsalis* and various biochemical parameters of chilli germplasm revealed that the population of *S. dorsalis* showed significant negative correlation with phenol (-0.975**), non-reducing sugars (-0.985**), chlorophyll a (-0.980**), chlorophyll b (-0.987**) and total chlorophyll (-0.990**) (Table 3). However, the relationship between proline (0.961**), protein (0.961**), total sugars (0.989**) and reducing sugars (0.989**) content of chilli leaves and the population of *S. dorsalis* was significantly positive.

The multiple linear regression analysis indicated that various biochemical parameters of chilli germplasm *viz.*, proline (X1=0.0247), phenol (X2=0.1165), protein (X3=0.0323), total sugars (X4=0.0367), reducing sugars (X5=0.0646), non-reducing sugars (X6=2.1829), chlorophyll a (X7=0.0435), chlorophyll b (X8=0.0654) and total chlorophyll (X9=0.0308) together influenced the population of *S. dorsalis* to an extent of 97.32 per cent (Table 4).

Table 3: Correlation coefficient (r) of incidence of *S. dorsalis* with biochemical characters of chilli germplasm.

Incidence of *S. dorsalis*	**Biochemical constituents**								
	Proline (µ moles/ gram)	**Phenol** (mg/ g)	**Protein** (mg/ g)	**Total sugar** (%)	**Reducing sugar** (%)	**Non reducing sugars** (%)	**Chlorophyll a** (mg/ g)	**Chlorophyll b** (mg/ g)	**Total chlorophyll** (mg/ g)
Population of *S. dorsalis* (Nos./leaf)	0.961**	-0.975**	0.961 **	0.989**	0.989**	-0.985**	-0.980**	-0.987**	-0.990**

** Correlation is significant at the 0.01 level
* Correlation is significant at the 0.05 level

Table 4: Multiple linear regression equations depicting the influence of biochemical factors on incidence of *S. dorsalis* in chilli germplasm.

Incidence of *S. dorsalis*	**Regression Models**	**Coefficient of determination (R^2)**
Population of *S. dorsalis* (Nos./leaf)	**Y1**= 8.6710+0.0247*X1-0.1165*X2+0.0323*X3-0.0367*X4+0.0646*X5-2.1829*X6-0.0435*X7-0.0654*X8-0.0308*X9	97.32

Where, Y1 = Population of *S. dorsalis*, **X1 =** Proline, **X2 =**Phenol, **X3 =** Protein, **X4 =**Total sugars, **X5 =**Reducing sugars, **X6 =** Non-reducing sugars, **X7 =**Chlorophyll-a, **X8 =** Chlorophyll-b, **X9 =**Total chlorophyll.

CONCLUSION

The foregoing discussion lead to the inference that low proline, protein, total sugars and reducing sugar content and high contents of phenol, non-reducing sugar and total chlorophyll in the leaves contributed to imparting resistance in chilli germplasm to *S. dorsalis.* So these germplasm may be utilized for future breeding of leaf curl tolerant chilli lines.

FUTURE SCOPE

Biochemical estimation plays an important role in host plant resistance mechanism (Antibiosis) against chilli thrips, *S. dorsalis.* The present findings on role of each biochemical parameter would help in deciding suitable criteria for genetic improvement of resistance

Acknowledgement. The author thanks Dr. L.N. Mohapatra and Dr. P. Naresh for proper guidance and providing lab facilities in CHES-Central Horticultural Experiment Station, Bhubaneswar.

Conflict of Interest. None.

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How to cite this article: S. Leela Praveen, L.N. Mohapatra, P. Naresh and G.S. Sahu (2022). Impact of certain Biochemicals on the Expression of Resistance in certain Chilli Germplasm to Chilli Thrips, *Scirtothrips dorsalis* Hood. *Biological Forum – An International Journal, 14*(2): 1520-1526.