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Morphological diversity of trichomes and phytochemicals in wild and cultivated eggplant species

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ABSTRACT

An attempt was made to understand the diversity of trichomes both at morphological and chemical levels in wild (*Solanum viarum*, *S. mammosum*, *S. indicum*, *S. gilo*, *S. torvum*) and cultivated eggplant (*S. melongena*) species. Cultivated and wild eggplant species have morphologically and chemically diverse trichomes. The presence of specific type of trichomes, their densities and chemical composition varied across species. The wild species viz., *S. viarum* and *S. mammosum* have seven (Type II to VIII) morphologically distinguishable types of trichomes including two types of glandular trichomes (Type VI, VII) as against uniform occurrence of branched stellate trichomes (Type VIII) alone in cultivated species. Differences among the phytochemicals viz., phenols and flavonoid levels were also observed across the eggplant species and type of trichomes.

Key words: Brinjal, wild species, glandular trichemes, phenols, flavonoids.

INTRODUCTION

Trichomes are specialized epidermal cells present on plant surface, giving rise to bristle like outgrowths. These structures impart plants their characteristic pubescent or hairy texture, an insect non-preference (=antixenosis) trait. Non-preference refers to various physical features of host-plant which make them undesirable or unattractive either for oviposition or feeding by phytophagous insects. Trichomes may also complement the chemical defense of a plant by possessing glands which exude terpenes, phenolics, and alkaloids etc. that serve as insect olfactory or gustatory repellents. In the sense, these trichomes are involved in direct plant defense against insect attack, either by physical-hindrance, entrapment or by secreting toxic or behavior modifying chemicals (Duffey, 7; Wagner, 20), forming an essential integral component of host-plant resistance viz., antixenosis. Thus, the trichome type and density of host-pants may explain the specific host-pant associations, adaptations and herbivory patterns of phytophagous insects. Further, the variations in the trichome features serve as leads to study evolutionary trends, to evaluate existing systematic classifications and may provide supplementary evidence in tackling taxonomic problems (Anjana *et al.*, 3).

The family Solanaceae exhibits a remarkable diversity in the trichome type/ density and trichome dependent herbivore defense which have been extensively studied particularly in tomato, *Lycopersicon esculentum* L. (Luckwill, 13), *Datura wrightii* Regel(van Dam *et al.*,19), tobacco, *Nicotiana tabacum* L. (Akers *et al.*, 1), wild potato, *Solanum berthaultii* Hawkes, cultivated potato, *S. tuberosum* (Yencho *et al.*, 21). However, similar studies in the sister species *S. melongena* (common or cultivated brinjal/ eggplant) and its wild relatives are limited. In the present study, attempts were made to understand the morphological structure, distribution and chemical composition of trichomes in different wild relatives of eggplant *viz.*, *S. gilo, S. indicum, S. torvum, S. viarum, S. mammosum, S. macrocarpon* compared to cultivated *S. melongena (cv. Arka keshav).*

MATERIALS AND METHODS

The wild species of eggplants *viz.*, *Solanum gilo* (scarlet eggplant), *S. indicum* (Poison Berry), *S. mammosum* (Cow's udder), *S. viarum* (Sodom apple), *S. torvum* (Turkey berry), *S. macrocarpon* (African eggplant) were compared to cultivated eggplant, *S. melongena* cv. Arka keshav. All the test plants were field-grown at the experimental fields of Indian institute of Horticultural Research, Hessaraghatta, Bengaluru, India (12° 58' N; 77° 35'E). To confirm the trichome diversity within the common eggplant, *S. melongena,* a total of 188 accessions were observed (List enclosed as appendix I). For each test plant, three fully developed leaves were collected randomly, kept in polythene covers and brought to the laboratory for further studies. A Cork borer (0.5 cm diameter)

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was used to punch a disc of leaf and three such leaf discs were taken randomly from each leaf for trichome studies. Observations were made on the presence/ absence of different types of trichomes/ spines, their colour and density on both adaxial (=upper) and abaxial (=lower) surfaces separately using stereomicroscope. Different types of trichomes were identified as per standard procedures (Simmons and Gurr, 16).

Each individual trichome types from each species were excised for chemical analysis. Mixed-type trichome samples were isolated by scraping frozen leaf tissue in liquid nitrogen. The stellar trichomes were isolated by rubbing the leaf surface using needle/baby brush. The glandular heads from type VI and VII trichomes were collected using a modified procedure (Gang *et al.,* 8).

Fresh leaves from all the species of eggplants were subjected to SEM analyses to better understand the morphological structure of different types of trichomes. Small pieces of leaves were fixed in formaldehyde + acetic acid +alcohol (FAA) for 24h, dehydrated in an ethanol series, critical point dried, mounted on stubs with self-adhesive double sided carbon discs and sputter coated with gold. Observations and digital photographs were taken with (Quanta FEI-Netherland) scanning electron microscope at 15 kV.

Different types of trichomes isolated as described above from all eggplant species were further analyzed to estimate the respective chemical constituents. A sample of 2000 trichomes picked into 1ml of 80% methanol and the glandular trichomes were isolated according to Gang *et al.,* (8).

Total phenols present in the methanol extract were estimated by the Folin-ciocalteu method (Singleton and Rossi, 17). Methanol extract was mixed with FCR reagent, and the subsequent intensity of color development with 20% sodium carbonate reagent was read by measuring the absorbance at 700 nm using a spectrophotometer (Beckman DU64, Beckman Instruments International, SA, Switzerland). Results were expressed as milligrams of gallic acid equivalents.

Total flavonoid extract was determined as per standard procedures (Chun *et al.,* 6). Methanol extract (1 mL) was mixed with 0.3 mL of 5% $NaNO_2$ followed by 0.3 mL of 10% $AlCl_3$. After 1 min, 2 mL of 1M NaOH was added and diluted to 10 mL with double distilled water and mixed thoroughly. The absorbance of the pink color was measured spectrophotometrically at 510 nm and expressed as catechin equivalents.

RESULTS AND DISCUSSION

A total of seven types of different glandular and non-glandular trichomes (Type II- Type VIII) were found on the leaves of *S. viarum* and S*. mammosum*. However, Type VIII (arboriform or dendritic or stellar type branched) trichomes were present only on abaxial surface in both the species (Fig. 1). In *S. macrocarpon*, the leaves showed no trichomes or only a few trichomes of Type VI dispersed sparsely depending on the age of the leaf and ecotype. Whereas in all other species viz., *S. gilo, S. torvum, S. indicum, S. melongena* only branched stellar type trichomes (Type VIII) were prevalent (Table 1). In the *S. melongena* accessions, variations were observed with in the stellar type branched trichomes for both colour (either purple or whitish green or mixed) and number of branches (varying from 2-9) (Fig. 2). In *S. viarum*, *S. mammosum* and *S. indicum* spines were noticed on both adaxial and abaxial surfaces. The long spines were found interspersed with short spines with approximate length of 0.8–3.1 cm. In *S. viarum*, the numbers of spines were 32 and 88 respectively on adaxial and abaxial surfaces. In *S. mammosum*,

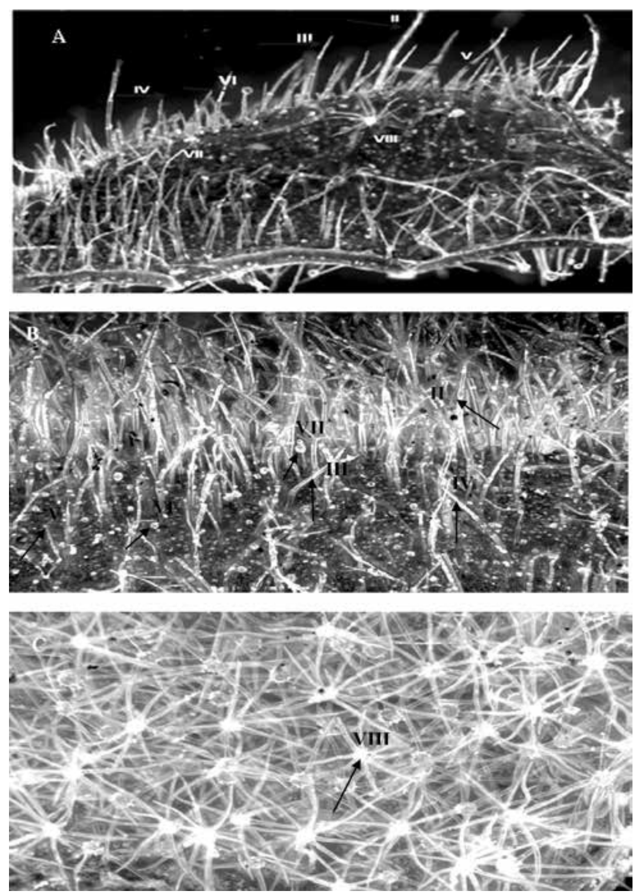

Fig. 1. Variation in leaf trichomes of different eggplant species, *S. viarum* leaf covered with multiple trichome types, II to VIII. (A), *S. mammosum* leaf trichomes (type II-VII) (B), *S. melongena* cv. Arka keshav leaf trichomes (type VIII) (C).

Table 1. Variations in trichome types/ density in different eggplant species.

Eggplant species	Leaf surface*	II	III	IV	V	VI	VII	VIII	Total count
S. mammosum	Ad	9 ± 0.88	40 ± 2.08	3 ± 0.33	11 ± 0.57	60 ± 0.88	30 ± 0.33	0	159
	Ab	15 ± 0.75	20 ± 0.33	2 ± 0.33	30 ± 0.57	60 ± 1.5	70 ± 1.56	8 ± 0.57	220
S. viarum	Ad	15 ± 1.0	45 ± 2.51	8 ± 1.52	30 ± 1.52	60 ± 1.15	12 ± 1.0	0	170
	Ab	25 ± 1.0	55 ± 2.5	11 ± 1.52	30 ± 1.52	70 ± 2.62	40 ± 1.52	15 ± 1.0	246
S. indicum	Ad	0	0	0	0	0	0	210 ± 1.66	210
	Ab	0	0	0	0	0	0	340 ± 0.66	340
S. gilo	Ad	0	0	0	0	0	0	120 ± 0.66	120
	Ab	0	0	0	0	0	0	260 ± 0.57	260
S. macrocarpon	Ad	0	0	0	0	10 ± 0.88	0	0	10
	Ab	0	0	0	0	8 ± 0.57	0	0	8
S. torvum	Ad	0	0	0	0	0	0	150 ± 2.9	150
	Ab	0	0	0	0	0	0	120 ± 0.88	120
*S. melongena***	Ad	0	0	0	0	0	0	110 ± 3.7	110
	Ab	0	0	0	0	0	0	240 ± 2.9	240

*Ad = adaxial surface, Ab = abaxial surface (=80 mm^2); **Arka keshav (Control)

the number of spines on adaxial/ abaxial surfaces were found to be almost similar and ranged between 7 –29. In *S. indicum*, they ranged from 11–17 on both the surfaces.

Of total seven types of trichomes, five were found to be non-glandular and present both on abaxial and adaxial surfaces of leaves, though their density was high on abaxial surface. Of these non-glandular trichomes, Types II, III, IV and V were both uni- as well as multicellular and unbranched. The type VIII trichome is branched stellar in structure with varying branches ranging from 2-9, with a pointed tip. The Types II, III and IV were sharply pointed at the distal end and approximately 20-200 µM in length (Fig. 1).

Of total seven types of trichomes that were observed in wild/ cultivated eggplant species, two types (Type VI and VII) were found to be glandular trichomes and found exclusively in *S. mammosum* (Type VI, 2-3; Type VII, 30-70 per 80 mm^2) and *S. viarum* (Type VI, 8-11; Type VII, 12-40 per 80 mm^2) species on both adaxial and abaxial surfaces (Table 1). However, in *S. macrocarpon*, sparsely dispersed Type VI trichomes (8-10/ per 80 mm^2) were found. Though the Type VI was distributed almost uniformly on both the surfaces, the Type VII was most prevalent on abaxial surface (Table 1). These glandular trichomes with short (Type VI) and long stalks (Type VII) consisted a unicellular stalk along with a spherical head. The characteristic spherical head of these secretary glandular trichomes may be due to the development of large sub-cuticular spaces and accumulation of secretions (Fig. 1). The Shannon diversity index (H) of trichomes fluctuated widely among the *Solanum* species where *S. viarum* recorded maximum (720.22), followed by *S. mammosum* (606.89). All other species viz., S. *indicum*, *S. gilo*, *S. torvum and S. melongena* recorded Zero Shannon diversity index as only one type of trichomes are prevalent. Among the different types of trichomes, the type VIII alone was present in cultivated eggplant species (*S. melongena*) and other wild species viz., *S. indicum*, *S. gilo*, *S. torvum*. However, in *S. viarum* and *S. mammosum* species, the dominant types were glandular trichomes viz., Type VI and Type VII (Table 1).

In general, significant differences were observed for trichome density on both adaxial (76.66 ± 1.90) and abaxial (121.58 ± 2.02) surfaces (F =262.98; df = 372; P < 0.001) in eggplant species. A significant positive correlation (r = 0.82**) was observed between trichomes present on adaxial and abaxial surfaces. Accordingly the variability in the trichome density on the leaf surface can be explained to the tune of 66% ($y = 0.8724x + 54.704$; $R^2 = 0.675$) through simple linear equation (Fig. 3). Generally, the trichome number was found to vary with different crop growth stages viz., vegetative, flowering and fruit formation stage, however, no significant differences were found between the stages (Table.2). The mean density of trichomes on adaxial surface ranged from 10.00 (*S.*

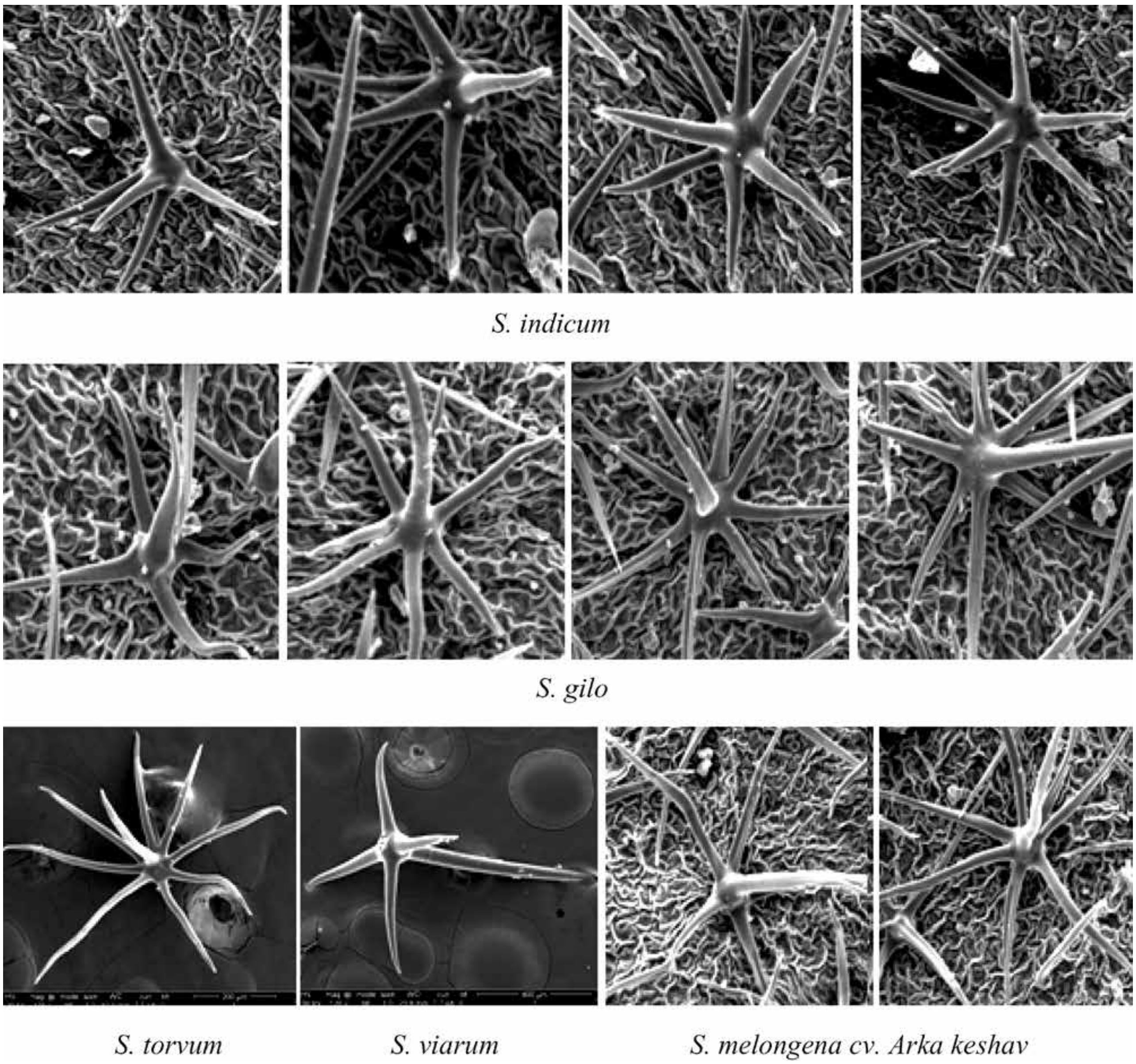

Fig. 2. SEM images of the non glandular stellar (Type VIII) trichomes with varying number of branches in wild and cultivated eggplant species.

macrocarpon) to 210.0 (*S. indicum*) and on abaxial surfaced ranged from 8.00 (*S. macrocarpon*) to 340.00 (*S. indicum*) (Table 2).

The total phenol content of different eggplant species revealed that *S. viarum* trichomes contained significantly highest content of phenols (2839±1.85 µg) followed by *S. mammosum* (1771 ± 0.88 µg) and *S. gilo* (1010 ±1.20 µg). The other species of eggplant, *S. torvum* (710±3.18 µg), *S .indicum* (700±1.85 µg), *S. melongena* (cv. Arka keshav) recorded comparatively lower phenol contents (700±3.71 µg). In *S. viarum*, among the different trichome types, Type VIII contributed highest amount of phenol content (1200±1.56 µg) followed by Type VII (1087±2.08 µg), Type VI (300 ±2.89 µg) and Type II (252±2.08 µg). In *S. mammosum*, Type VIII contributed highest amount of phenols (1000±1.52 µg) followed by Type II (335±1.66 µg), Type VI (238±1.20 µg) and Type VII (198±1.56 µg) (Fig.4A).

Conversely, among the eggplant species, significantly the highest flavonoid content was recorded in *S. mammosum* (1433±1.4 µg) followed by *S. viarum* (990±1.52 µg) and *S. indicum* (600±1.4µg). The cultivated species, *S. melongena* (cv. Arka Keshav)

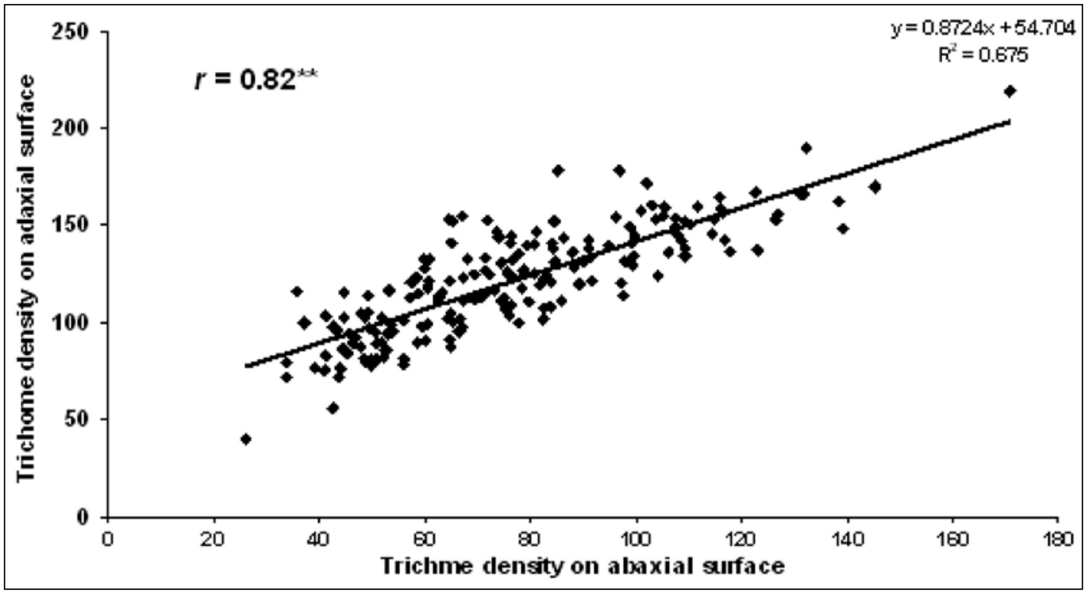

Fig. 3. Relationship between trichome density on abaxial and adaxial surface.

Table 2. Trichome density at different stages of plant growth in eggplant species.

Eggplant species	Density of trichomes (80 mm²)					
	Before flowering		After flowering		After fruiting	
	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial
*S. melongena**	157.10 ± 35.10	317.60 ± 9.40	75.30 ± 9.90	292.10 ± 8.20	263.30 ± 5.07	392.70 ± 3.60
S. mammosum	85.10 ± 7.60	167.70 ± 17.48	147.70 ± 31.90	267.30 ± 20.61	369.60 ± 17.50	392.01 ± 28.91
S. viarum	113.30 ± 4.80	177.70 ± 13.40	383.10 ± 3.80	406.30 ± 3.38	377.01 ± 34.02	412.10 ± 4.85
S. gilo	25.70 ± 3.39	296.60 ± 3.33	29.40 ± 3.10	289.60 ± 8.82	28.30 ± 1.93	340.10 ± 4.85
S. indicum	168.30 ± 8.20	336.30 ± 1.20	109.40 ± 5.02	352.60 ± 9.85	97.20 ± 31.70	399.3 ± 5.07
S. macrocarpon	31.70 ± 2.50	22.10 ± 5.00	17.50 ± 7.60	3.70 ± 1.30	30.10 ± 15.07	10.1 ± 1.02

*Arka keshav (Control)

recorded the lowest flavonoid content (300±4.2μg). In *S. mammosum*, the trichome Types VIII, II, VI and VII contributed towards total flavonoid content in the descending order viz., 858±3.79, 311±1.76, 141±0.88, 123 ± 0.88 μg/ml respectively. Whereas, in *S. viarum*, the trichome Type VIII contributed to maximum amount of flavonoids (450±1.45 μg) followed by Types VI (200±1.20 μg), II (190±2.08 μg) and VII (150±2.08 μg) (Fig.4B). The chemical analysis of trichomes among the eggplant species clearly showed that variations do exist in both phenols as well as flavonoid contents. Further, variations were also evident among the different types of trichomes.

Plant structural traits, such as spinescence, pubescence, trichomes etc play a role in protecting plants from herbivore attack thereby serving as anti-herbivore defense (Hanley *et al.,* 11). Among several plant structural traits, trichomes contribute to plant resistance against herbivory by physical as well as chemical deterrents particularly in Family, Solanaceae (Tian *et al.*, 18). Plant glandular trichomes in particular have been studied widely for their metabolic diversity as targets for breeding or engineering of resistance to herbivores particularly in Solanaceous plants like tomato (Glas *et al.,* 9). Nevertheless, the studies explaining the trichome based differences in both wild as well as cultivated eggplant species, a member of Solanaceae are rather limited in spite of their observed differential susceptibility to herbivores like leaf hopper, *Amrasca biguttula* Ishida (Homoptera: Cicadellidae), eggplant shoot and fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae) and several experiments involving wild species of *Solanum* viz., *S. macrocarpon, S. viarum* etc to obtain shoot and fruit borer resistance have been carried out (Gowda *et al.,*10; Anis *et al.,* 2;

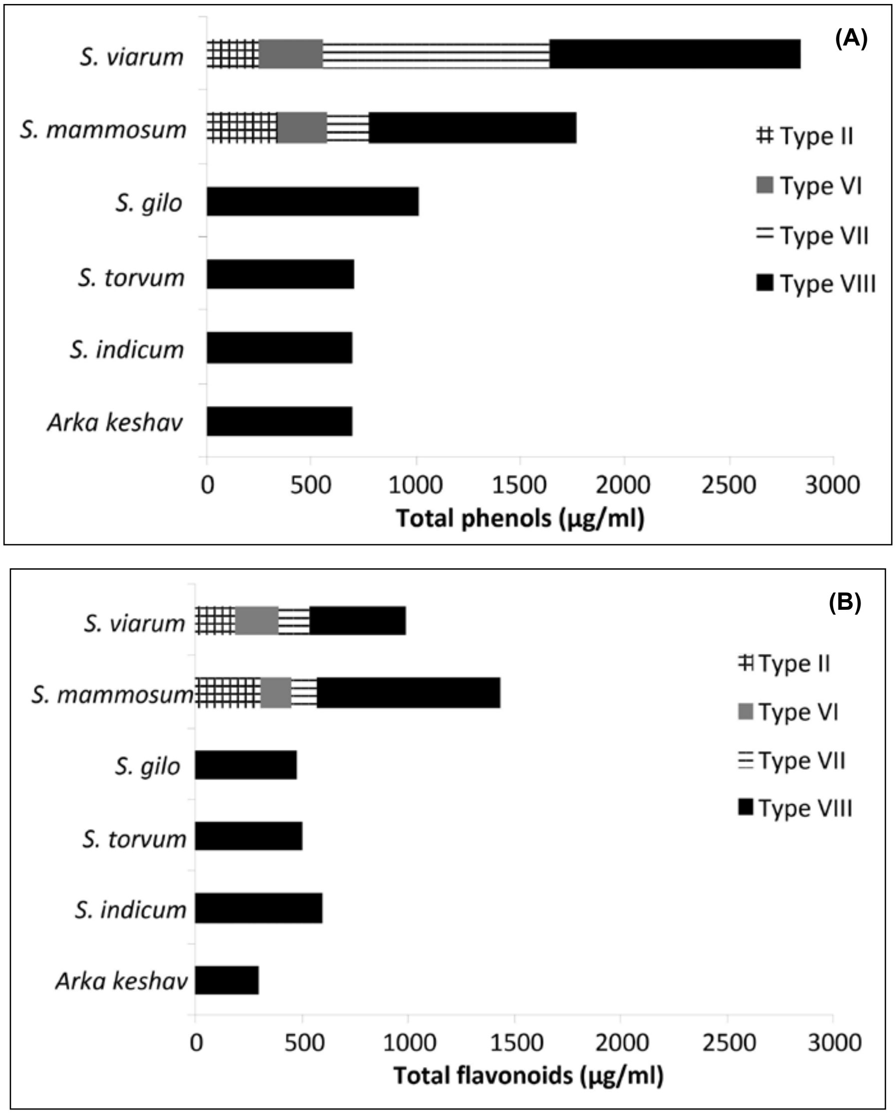

Fig. 4. Estimation of total phenols and flavonoids in trichomes of wild/ cultivated eggplant species. Total phenols (A), Total flavonoids (B).

Behera and Singh, 4; Praneetha, 14; Pugalendhi *et al.,* 15).

In this present study, we aim to outline the comparative differences of the morphological structure, distribution and chemical composition of trichomes in both wild as well as cultivated eggplant species. The results revealed the underlying differences not only in trichome types, but also the density as well as their chemical composition in wild eggplant species *viz*., *S. viarum*, *S. mammosum* to cultivated eggplant species, *S. melongena*. Clear differences were observed among the species for trichome density as well as type of trichomes on both abaxial and adaxial surfaces of leaf (80 mm^2). A total of seven types of glandular and non-glandular trichomes were observed in wild as well as cultivated *Solanum* species (Fig. 1). Of different types of trichomes, stellar trichomes (Type VIII) were found to be abundant in *S. melongena, S. indicum S. gilo* and *S. torvum.* Whereas, in *S. mammosum* and *S. viarum*, besides stellar trichomes, the other Types II to VII were also present exhibiting a tremendous diversity in both glandular and non-glandular trichomes. With regard to trichome diversity, the cultivated eggplant species viz., *S. melongena* along with other species like *S. indicum*, *S. gilo* and *S. torvum* did not exhibit any trichome diversity and almost homogeneous with Type VIII stellar trichomes and *S. macrocarpon* was almost found to be glabrous. Conversely, a study on trichome characteristics of eleven species belonging to the genus *Solanum* reported a wide range of variation with many of the members exhibiting up to 5 – 6 different types of trichomes, with maximum trichome type diversity in *S. torvum, S. nigrum, S. melongena, S. indicum, S. pubescence* and *S. macranthum* (Anjana *et al.,* 3).

Phenols and flavonoids are the major secondary metabolites present in plants protecting the tissues from insect attacks contributing towards antifeedant activity against larvae. Estimation of total phenols and flavonoid contents in trichomes showed that these are higher in wild eggplant species than cultivated. Among the different phytochemicals, the phenols exhibited significant negative correction with eggplant shoot and fruit borer, *L. orbonalis* (Chandrashekhar *et al.,* 5). In the present study, the differences were observed for types of trichomes, their densities and chemical composition across eggplant species. Similar studies on other *Solanaceous* members' viz., tomato showed that cultivated tomato and its wild relatives have morphologically and chemically diverse trichomes (Kim *et al.,* 12). Several previous studies clearly showed the role of glandular trichomes as an apparent first line defense at the surface of the plant (Wanger, 20). Thus, the detailed studies to understand the precise chemical characterization of each trichome type and exact role of glandular/ non-glandular trichomes (physical as well as chemical hindrance) in bringing down the reported herbivore incidence in wild/ cultivated eggplant species are being envisaged.

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REFERENCES

1. Akers, P.C., Weybrew, J.A. and Long, R.C. 1978. Ultra structure of glandular trichomes of leaves of *Nicotiana tabacum* L., cv Xanthi. *American J. Bot.* **65**: 282-92.
2. Anis, M., Baksh, S. and Iqbal, M. 1994. Cytogenetic studies on the F_1 hybrid *Solanum incanum* × *S. melongena* var. American Wonder. *Cytologia*, **59**: 433-36.
3. Anjana, V.N., Kumari, N.O. and Mathew, P.M. 2008. Intra-specific variations of trichomes in the genus *Solanum* L. **In***: Biodiversity conservation,* Binoj Kumar, MS, Gopalakrishnan, PK (ed.) pp. 109-14.
4. Behera, T.K. and Singh, N. 2002. Interspecific hybridization in eggplant for resistance to shoot and fruit borer. *Capsicum & Eggplant Newslet.* **21**: 102-05.
5. Chandrashekhar, C.H., Malik, V.S. and Singh, R. 2008. Morphological and biochemical factors of resistance in eggplants against *Leucinodes orbonalis* (Lepidoptera: Pyralididae). *Ento. Gen.* **31**: 337-45.
6. Chun, O.K., Kim, D.O., Moon, H.Y., Kang, H.G. and Lee, C.Y. 2003. Contribution of individual polyphenolics to total antioxidant capacity of plums. *J. Agr. Food Chem.* **51**: 7240-45.
7. Duffey, S.S. 1986. Plant glandular trichomes: their partial role in defence against insects. **In**: *Insects and the plant surface*, Juniper, BE, Southwood, TRE. (ed.), London. pp. 151-72.
8. Gang, D.R., Wang, J., Dudareva, N., Nam, K.H., Simon, J., Lewinsohn, E. and Pichersky, E. 2001. An investigation of the storage and biosynthesis of phenylpropenes in sweet basil (*Ocimum basilicum L.*). *Plant Physiol*. **125**: 539-55.
9. Glas, J.J., Schimmel, B.C.J., Alba, J.M., Escobar-Bravo, R., Schuurink, R.C. and Kant, M.R. 2012. Plant glandular trichomes as targets for breeding or engineering of resistance to herbivores. *Int. J. Mol. Sci.* **13***:* 17077-103.
10. Gowda, P.H.R., Shivashankar, K.T. and Joshi, S. 1990. Interspecific hybridization between *Solanum melongena* and *Solanum macrocarpon*. Study of the F_1 hybrid plants. *Euphytica*, **48**: 59-61.
11. Hanley, M.E., Lamont, B.B., Fairbanks, M.M. and Rafferty, C.M. 2007. Plant structural traits and their role in anti-herbivore defence. *Perspect. Plant Ecol.* **8**: 157-78.
12. Kim, J., Kiyoon, K., Eliana, Gonzales-Vigil, Feng, S., Daniel, J.A., Cornelius, S.B. and Robert, L.L. 2012. Striking natural diversity in glandular trichome acylsugar composition is shaped by variation at the Acyltransferase2 locus in the wild tomato *Solanum habrochaites*. *Plant Physiol*. **160**: 1854-70.
13. Luckwill, L.C. 1943. The genus *Lycopersicon*: An historical, biological and taxanomic survey of the wild and cultivated tomatoes. Aberdeen University press, UK.

14. Praneetha, S. 2002. Breeding for shoot and fruit borer (*Leucinodes orbonalis* G.) resistance in brinjal (*Solanum melongena* L.). Ph.D. thesis, Tamil Nadu Agricultural University, Coimbatore.

15. Pugalendhi, L., Veeraragavathatham, D., Natarjan, S. and Praneetha, S. 2010. Utilizing wild relative (*Solanum viarum*) as resistant source to shoot and fruit borer in brinjal (*Solanum melongena* Linn.). *EJPB* **4**: 643-48.

16. Simmons, T.A. and Geoff, M.G. 2005. Trichomes of *Lycopersicon species* and their hybrids: effects on pests and natural enemies. *Agr. forest. Ento.* **7**: 265-76.

17. Singleton, V.L. and Rossi, J.A. 1965. A colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. *American J. Enol. Vitic*. **16**: 144-58.

18. Tian, D., Tooker, J., Peiffer, M., Chung, S.H. and Felton, G.W. 2012. Role of trichomes in defense against herbivores: comparison of herbivore response to woolly and hairless trichome mutants in tomato (*Solanum lycopersicum*). *Planta*, **236**: 1053-66.

19. Van Dam, N.M., Hare, J.D. and Elle, E. 1999. Inheritance and distribution of trichome phenotypes in *Datura wrightii. J Hered.* **90**: 220-27.

20. Wagner, G.J. 1991. Secreting glandular trichomes: more than just hairs. *Plant Physiol*. **96**: 675-79.

21. Yencho, G.C. and Tingey, W.M. 1994. Glandular trichomes of *Solanum berthaultii* alter host preference of the Colorado potato Beetle, *Leptinotarsa decemlineata*. *Ento. Exp. Appl.* **70**: 217-25.

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