

Morphology, Structure and Distribution of Floral Trichomes in *Coccinia grandis* (L.) Voigt. (Cucurbitaceae)

Raseena, N.R* and Suhara Beevy, S.

Department of Botany, University of Kerala, Kariavattom campus, Thiruvananthapuram, Kerala, India

Corresponding author: raseenanrnn@gmail.com (ORCID ID: 0000-0003-2360-9110)

Paper No. 708

Received: 22-03-2018

Accepted: 19-05-2018

ABSTRACT

Trichomes are epidermal appendages found in plant parts, have an important role in growth, development and pollination. The present study have been investigated the morphology, structure and distribution of trichomes on the reproductive parts of *Coccinia grandis*, a dioecious species in Cucurbitaceae, using micro and macroscopic studies. On the basis of structure and function, the epidermal hairs are classified under glandular and non-glandular trichomes. Three types of glandular (peltate, capitate and conoidal) and four types of morphologically distinct non-glandular hairs were observed. Distribution of hairs varies according to parts of flower. Non-glandular hairs developed earlier and their density reduces in later stages except in corolla, whereas glandular hairs were predominant in mature flowers. The study pointed out that the floral trichomes in *Coccinia grandis*, play an important role in effective pollination rather mechanical support.

Highlights

- ① Floral trichomes in *Coccinia grandis* demonstrated an uneven distribution on different floral parts during the floral morphogenesis.
- ② They exhibit great structural diversity, include both glandular and non- glandular hairs and have different functions on each floral whorls ranging from mechanical support to pollination.

Keywords: Glandular trichomes, Non-glandular hairs, Pollination.

Trichomes, the epidermal hairs are common across plants, and distributed on the surface of vegetative and reproductive parts. Due to its diversity in morphology, structure and distribution, trichomes can be used as a taxonomic marker (Wang *et al.* 2004). Trichomes are distributed at the surface of aerial plant parts, perform various functions like reduce heat load, enhance water absorption, increase tolerance to freezing, protect plant structure from harmful effects of sunlight, aid seed dispersal, protect plants from herbivorous and pathogens (Kennedy 2003).

Trichomes are often classified as glandular or non-glandular based on their secretory function (Peterson and Vermeer 1984). They are considered as the physical barriers against external factors and also serve to restrict loss of water, extreme

temperature and ultraviolet radiation (Werker 2000). Glandular trichomes produce secondary compounds that are helpful for pollination, defense and protection (Mahlberg and Kim 2004). The nature of trichome and its secretory substances vary among species and are used in systematics (Wagner 1991). Glandular trichomes on leaves were extensively studied in many families like Lamiaceae (Bruni and Modenesi 1983), Solanaceae (Adedeji *et al.* 2007), Cucurbitaceae (Kolb and Muller 2004); whereas on reproductive organs the reports were limited (Werker 1993). (Tan *et al.* 2016) suggested that floral trichomes help to keep flower bud in its proper shape until the emergence of full bloom.

Coccinia grandis (L.) Voigt belonging to Cucurbitaceae, commonly known as ivy gourd; is a strictly

dioecious species. Dioecy is a rare condition in plants and it appears to be rather more common among dicot genera than among monocots and particularly prevalent in some families including Cucurbitaceae (Renner and Ricklefs 1995). The species is unique by the presence of heteromorphic sex chromosomes (Roy 1974). The mature male and female flowers have structural similarity in their outer whorls; both possess five sepals and five united petals. However the sexual whorls are quite variable. The male flower has three fused stamens with a thick filament while ovary is inferior with a single style and a trifid stigma in female flower. The present work based on micromorphology and floral anatomy provides new elements on morphology, structure and localization of glandular and non-glandular thichomes in the flowers of *C. grandis*.

MATERIALS AND METHODS

The male and female populations of *C. grandis* (15 plants from two groups) growing in the Botanic Garden, Department of Botany, University of Kerala, were considered for the present study. Buds and flowers of both male and female plants were examined.

Trichome morphology

Fresh floral parts of *C. grandis* were examined using an Olympus SZ 61 stereomicroscope, connected to an ultrascope digital camera for the identification of morphological characters.

Floral anatomy

The floral parts of *C. grandis* from buds and mature flowers were fixed in FAA, stored at 4°C for 12 hours. Sections were prepared according to paraffin method (Algan 1981). The material was dehydrated in an alcohol series, then replaced by an ethanol: xylene series before being infiltrated with paraffin wax, kept at 58°C. Wax blocks were cooled on ice and sectioned at 6–7 µm thickness using a rotary microtome.

The slides were subjected to following histochemical analysis: toluidine blue (TBO); a nonspecific, polychromatic stain that binds to most cellular components except starch and lipid (O'Brien and McCully 1982), Sudan IV for total lipids, ferric trichloride for phenolic compounds (Johansen 1940) and protein. The stained materials were studied and

photographed using a LEICA GFC 425 C image microscope.

Scanning electron microscopy

Floral buds and petals from fully expanded flowers were collected and fixed in FAA at room temperature for 24 hours and dehydrated in alcohol series. The specimens were dried to critical point with CO₂ then coated with gold and viewed with a So -2400 (Hitachi) SEM, and photographed using digital image scanning system.

RESULTS AND DISCUSSION

Micromorphological observations of reproductive parts of *C. grandis* revealed that the adaxial and abaxial surfaces of all floral whorls possessed trichomes. Detailed evaluation of trichomes showed the presence of both glandular and non-glandular types ranged from unicellular to multicellular. They varied in their length and number of cells, size of head and nature of apical cell (Table 1). The pattern of distribution of trichomes on different floral parts were depicted in the graphs (Fig. 1 A&B).

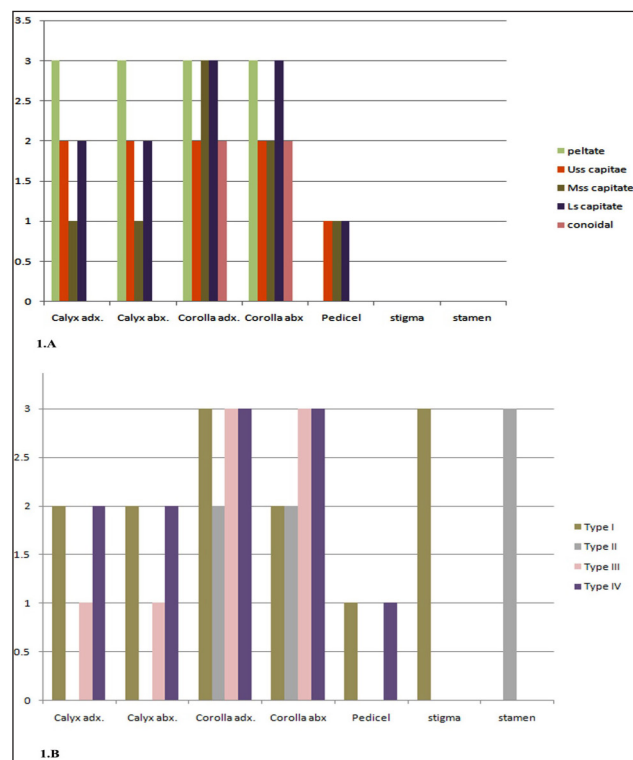
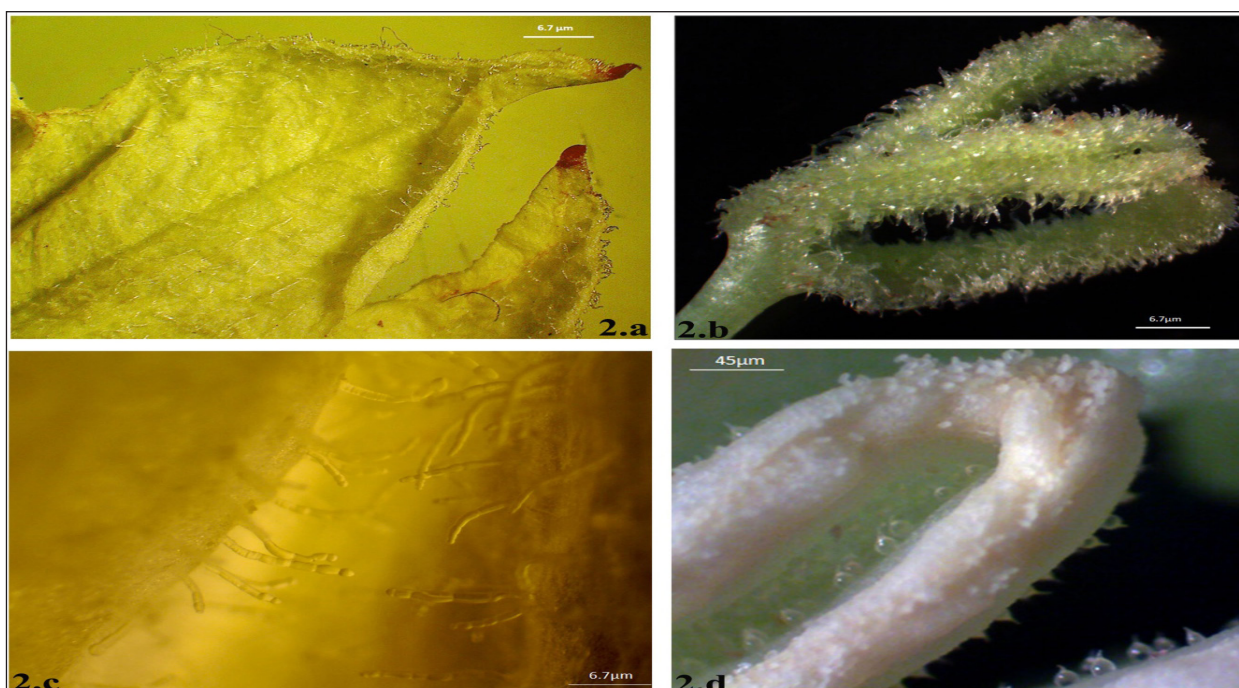


Fig. 1: Distribution of glandular (1A) and non glandular trichomes (2A) on the different parts of flower in *C. grandis*. SS-short stalked capitates, LS-Long stalked capitates, USS-Unicellular short stalked, MSS-Multicellular short stalked capitate trichomes (0 : absent, 1: present, 2: medium coverage, 3: dense coverage).

Table 1: Size of glandular and non glandular hairs in the flowers of *C.grandis*. SS-Short stalked, USS-Uni cellular short stalked, MSS-Multi cellular short stalked, LS-Long stalked capitate trichomes

	<i>Glandular trichomes</i> (µm)				<i>Non-glandular trichomes</i> (µm)				
	peltate	capitate			conoidal	Type I	Type II	Type III	Type IV
		SS	USS	MSS					
Length of trichome	16.46±1.4	51.5±2	46.06±0.5	89.0±1.3	67.8±0.9	42.6±0.2	28.9±0.7	92.4±0.3	159.3±2
Length of head/ apical cell	12.39±0.7	27.7±0.8	17.84±0.5	18.4±0.7	46.8±0.8	20.9±0.7	7.5±0.3	32.3±0.8	7.8±0.6
Width of head/ apical cell	18.33±1.3	30.98±0.67	19.3±0.4	14.6±0.9	32.8±0.6	18.7±0.8	11.2±0.6	10.4±0.2	8.5±0.4

**Fig. 2:** Stereomicroscopic image of floral parts. 1. Surface of Petal, 2. Stigmatic surface of female flower, 3. Surface of petal showing long stalked glandular hairs (arrow). 4. Anther lob with Type II non glandular hairs (arrow).

Glandular Trichomes

Based on morphology and structure of secretory head, the glandular trichomes observed in the flowers of *C.grandis* were categorized into peltate, capitate and conoidal. On the basis of length of stalk cell, capitate type was further divided into short and long stalked trichomes.

Peltate hairs

The peltate hair consisted of a basal cell embedded in epidermis with multicellular stalk and a large secretory head, consisted of 4-6 secretory cells (Fig 3.A). The anticlinal wall of stalk cell and cells of secretory head had a thick cuticle and a sub

cuticular space. The elevated space of cuticle of head accumulates secretory material. SEM observations could not observe any specific subcellular cuticle or pores/openings in the surface of secretory head (Fig 5.A). The secretory material may be exuded slowly through thin cuticle or by breaking cuticular wall by external forces.

Capitate Trichomes

Capitate trichomes consisted of a base, a stalk with 1-8 cells and a unicellular to multi cellular head. These trichomes were quite variable in size, morphology and distribution. Based on morphology of glandular head and secretion process, capitate trichomes were subdivided into short stalked (uni/

multicellular head) and long stalked in which the former has a basal cell a stalk and a uni or bi cellular ovoid to globular head covered by a thin cuticle (Fig 3. B&C). The multi cellular headed capitate trichome had four celled head and a short secretory cell (Fig 3.D) whereas, long stalked glandular trichomes showed 2-8 celled stalk, a neck cell and a globular head with secretory cell (Fig 3.E). The cuticle was thick and pores were observed on the surface of head (Fig 5.A).

Conoidal trichome

They were rare type of glandular trichome present on the both the surfaces of corolla. They had a small uni cellular base, 2-4 celled stalk, uni cellular neck and a multicellular (4-6) conoidal head. The

thick cuticular membrane was and a sub cuticular membrane were observed (Fig 3.F).

Histological analysis of glandular trichomes revealed the presence of polysaccharides, phenols, lipophilic compounds and proteins (Fig 4 D-F).

Non-glandular trichomes

Most commonly found trichomes in the flowers of *C. grandis* were non-glandular type. All the floral parts except anther were covered with non-glandular trichomes. The floral primordia were covered by numerous multi cellular unbranched non-glandular hairs. Based on the number of cells and nature of apical cell, they can be categorized into four types.

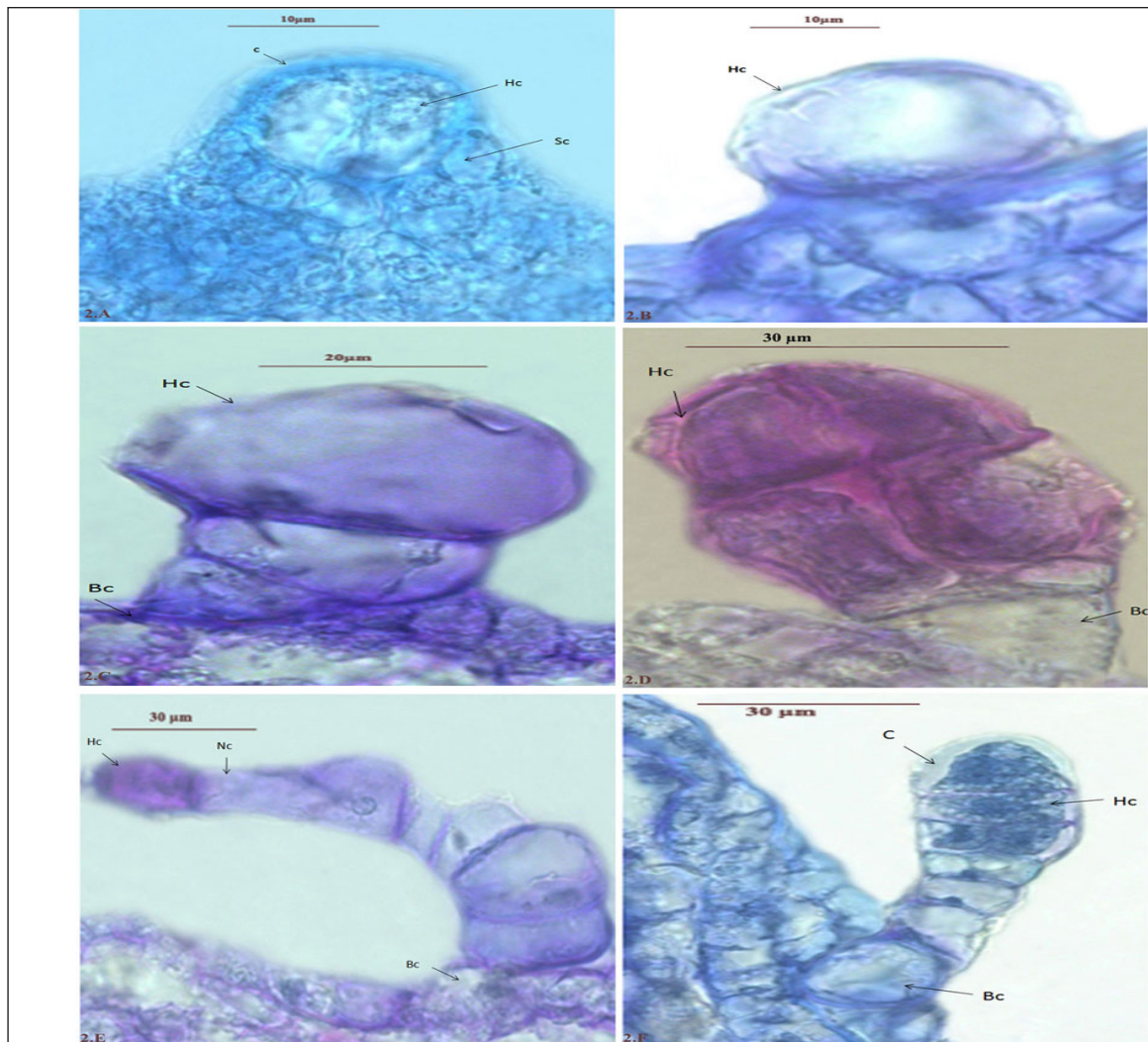


Fig. 3: Different types of Glandular hairs in flowers of *Coccinia grandis*. a. Structure of peltate hair. b. Short stalked uni cellular glandular trichome. c. Short stalked bicellular glandular trichome. d. Short stalked multicellular headed capitate trichome. e. Long stalked capitate trichome. f. conoidal trichome. (C-Cuticle, CS subcuticular space, Hc-Head cell, Sc-Secretory cell, Bc-base cell, Nc-neck cell).

Type I: Bicellular trichome with normal basal cell and a pointed apical cell. They were distributed in all parts (except anther) of the flower along with other trichomes (Fig 4.A).

Type II: Bicellular non-glandular trichome with a stout basal cell and a pointed apical cell. The cuticular surface of wall of apical cell is covered by numerous striations (Fig 4C, 5E).

Type III: Multi cellular uniseriate stalk with pointed apical cell (hooked). The trichomes were abundant in both abaxial and adaxial surface of petal. They are composed of 2-5 basal cells and a pointed apical cell. The apical part of the cell bends at different directions (Fig. 4D).

Type IV: Multi cellular non-glandular hairs with normal basal cell, shrivelled middle cell and pointed apical cell. These types of hairs were observed in the petal and pedicel. They were very long and composed of 5-9 cells (Fig. 5F).

The presence of three different types of glandular and four types of non-glandular hairs distributed in almost all parts of the flowers revealed trichome diversity in *C.grandis*. This is the maiden report for *C.grandis* on floral trichomes. Highest density of both types of trichomes was observed both on the surfaces of corolla. The diversity of hairs in flowers of *C.grandis* suggested their significance in the secretion of exudates that may guide insects

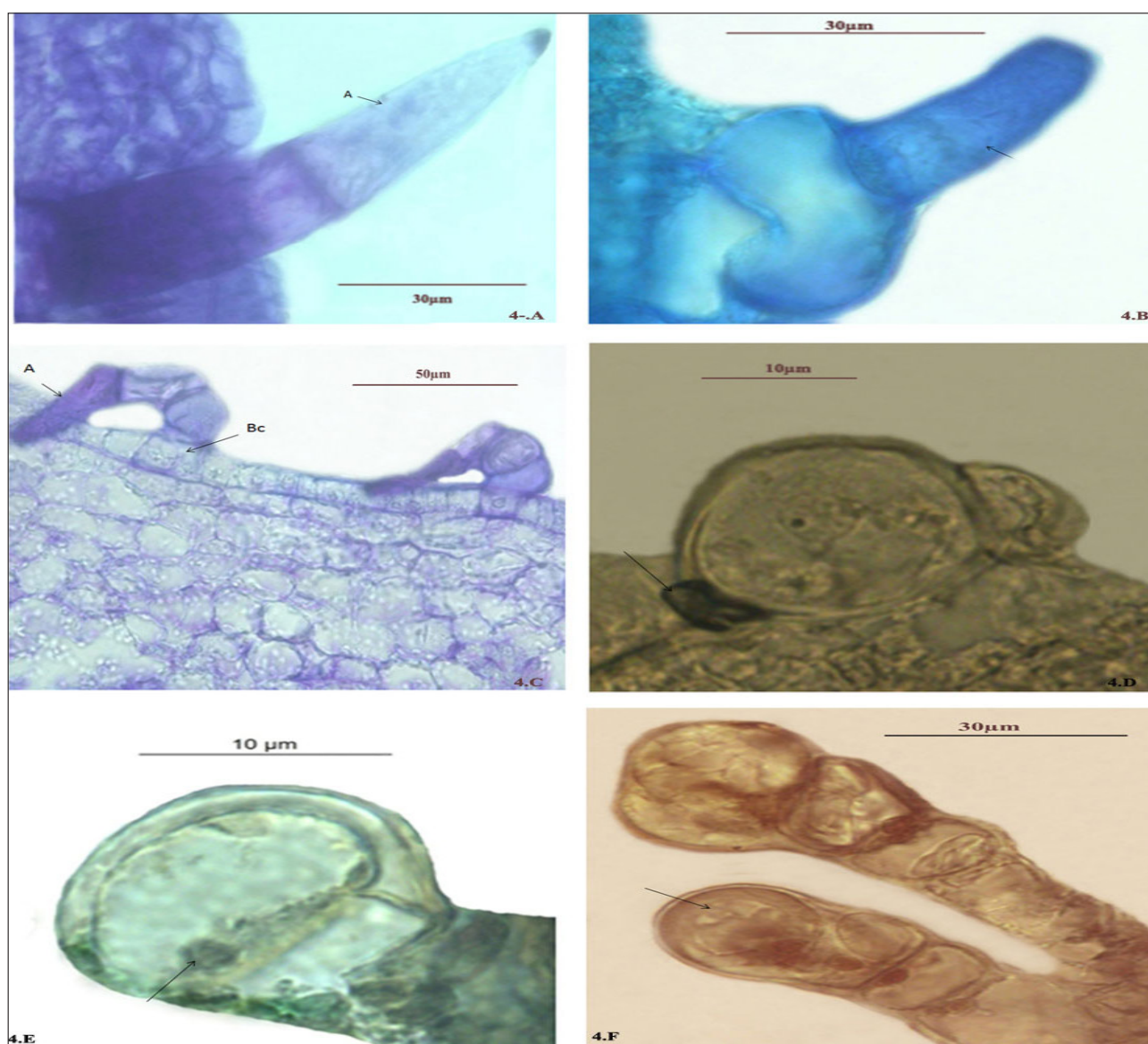


Fig. 4: Types of non glandular hairs in the flower. A. Type I, B. Type II, C. Type III. D-localization of phenolic compound in peltate trichome. E. Presence of phenols in unicellular short stalked capitate trichome. F. long stalked trichome stained with Sudan IV.

or act as floral rewards to pollinators. According to Ascensao *et al.* (1999), glandular hairs varied in morphology, structure and density among species and organs. The study revealed maximum density of glandular trichomes in the petals of full bloomed flowers than in the bud stage, indicates the influence of light on differentiation of glandular trichomes. According to Thanki (1989) glandular trichomes were rare and few celled in the leaves of *C.grandis*. Present findings noticed abundance of peltate hairs on both the surfaces of corolla, while in other floral parts distribution was rare. Peltate hairs were simple type of glandular trichomes in the flowers of *C.grandis* having a head cell and small secretory cells. At maturity, head cell was about $12.39 \pm 0.7 \mu\text{m}$

height and $18.33 \pm 1.3 \mu\text{m}$ in diameter. The number of secretory cells varied from four to six. Variations in the number of secretory cells in the peltate hairs (ranged from four to eight) was reported in species like *Salvia* (Kahraman *et al.* 2010).

The capitate hairs were widespread in the flowers of *C.grandis*, especially in calyx and corolla. They were more variable than peltate trichome regarding length of the stalk cells and shape of secretory head. Short stalked trichome was abundant on both the surfaces of corolla, while moderately distributed in the calyx. Short stalked hairs differed in the number of head cells, unicellular capitate trichome having an average length of about 46.06 ± 0.5 with 17.84 ± 0.5 , 19.3 ± 0.4 length and width of head cell respectively

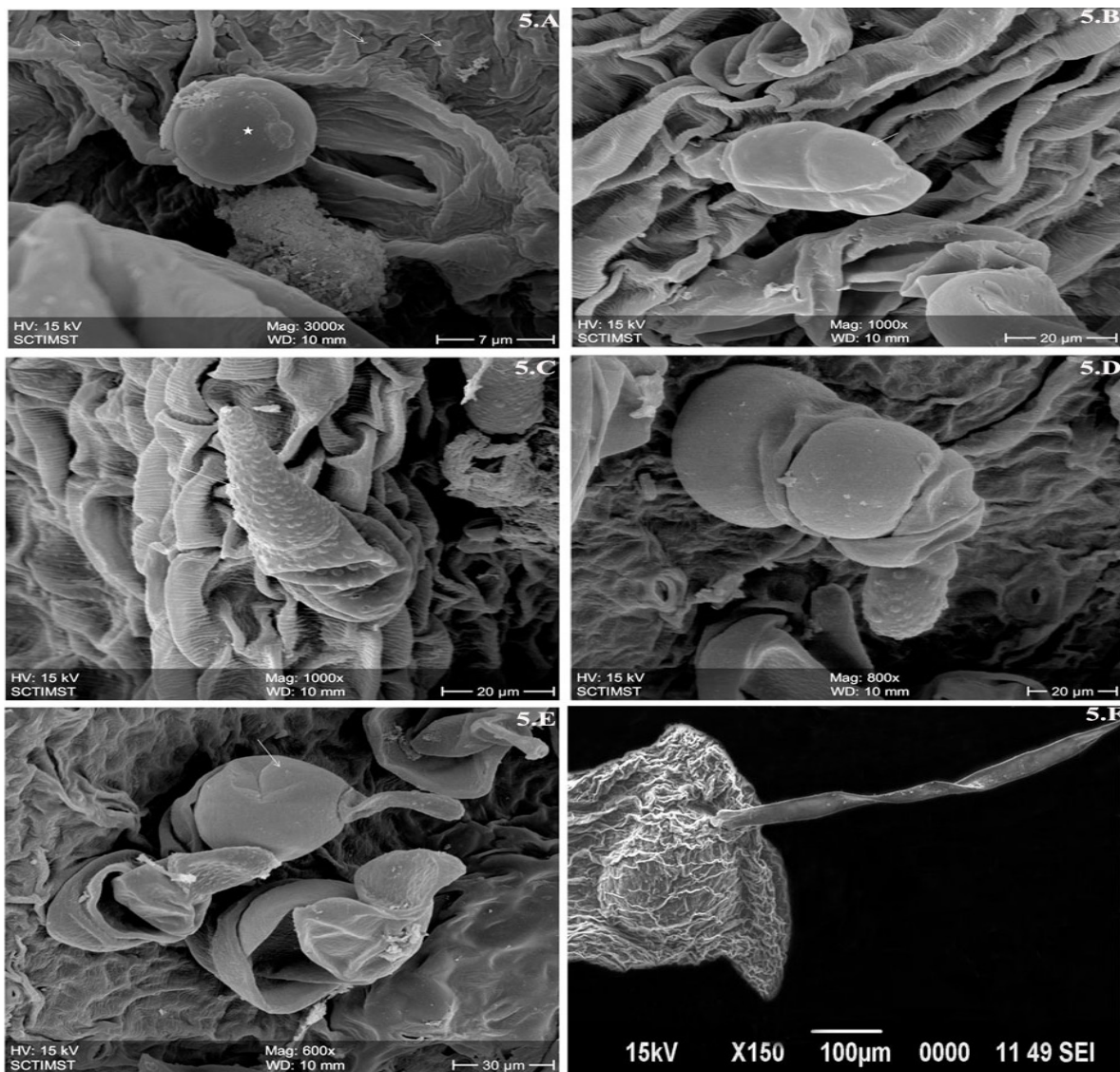


Fig. 5: SEM images of glandular and non glandular hairs. a. Long stalked capitates hair (star) and peltate hairs (arrow). b. short stalked capitate trichome with multi cellular head. c. Type I. d. Type III. e. Type II (arrow). f. Type IV non glandular hair.

whereas multicellular capitate trichome having a length of 51.5 ± 2 with 27.7 ± 0.8 head length and 30.98 ± 0.4 width. Variations in the number of secretory cells in the capitate trichomes were reported by Corsi and Bottega (1999); Bisio *et al.* (1999). Large number of single capitate unicellular head with 2-3 celled stalk and rarely short stalked with two celled head were reported in the corolla of *Euphrasia stricta* (Haratym and Chmielewska 2014).

The presence of abundant long stalked capitates glandular trichomes with multicellular stalk, a secretory cell, a short neck cell and a globular head were observed on both the surface of corolla *C. grandis*. The neck cell was thin compared to other cells. The secretory materials exuded through the surface of head may attract insects for effective pollination in *C. grandis*. Neck cell in the glandular trichomes prevents the backflow of secreted substances through the apoplast (Baran *et al.* 2010). Krings *et al.* (2003) reported similar type of trichome in *Sicana odorifera* (Cucurbitaceae). Morphological variations in the long stalked capitates trichomes were reported in the different species of Lamiaceae (Mota *et al.* 2013). In *Ocimum selloi*, stalked capitate trichomes were observed on the adaxial surface of sepal, whereas it was completely absent in petals, stamens and gynoecia (Goncalves *et al.* 2010). The study found out presence of a rare type of glandular trichome with an average length of 67.8 ± 0.9 consisting of a small unicellular base, 2-4 celled stalk and a multicellular conoidal head on both the surfaces of corolla in *C. grandis*. The *Plectranthus* species also exhibited the same in the calyx and corolla (Ascensao *et al.* 1999).

The glandular trichomes present in the flowers of *C. grandis* secrete hydrophilic polysaccharides, phenolic compounds, lipophilic substances, that probably repel pathogen attacks. The hydrophilic polysaccharides can improve water retention and water vapor absorption through cuticle and act as a physical barrier, protecting young organs from dehydration (Mayer *et al.* 2013). According to Werker (2000) glandular trichomes produce large amount of phytotoxic substances than that of internal tissues. The exact function of secretion of glandular hairs is not known but it may be involved in the chemical defense or serve to attract pollinators. The interaction of polysaccharides with phenolic compounds traps phytophagous insects (Tingey and Gibson 1978).

The long non-glandular trichomes with basal cells providing a strong point of attachment that anchors the trichomes to cover and shield the surrounding glandular trichomes. Dense distribution of both short and long non-glandular trichomes in close association with glandular trichomes suggests the protective function of non-glandular trichomes by shielding glandular trichomes in the flowers of *C. grandis*. Trichomes with elongated cells protect shorter glandular trichomes by their disposition and forming fibre meshes over these gland (Lusa *et al.* 2014), limiting exposure to ultra violet radiation, limiting water loss, acting as defence against herbivorous predators (Wagner *et al.* 2004). Distribution of non-glandular trichomes on the epidermis is a characteristic shown by most of angiosperms and could be associated with protection against insects (Fahn 1988).

The study noticed presence of non-glandular trichomes throughout the development of flower in *C. grandis*. The floral primordia were covered by numerous multi cellular unbranched non-glandular hairs. This may be an adaptive mechanism against herbivores which are attacked by younger plant parts. Previous reports suggested that many plant species respond to insect damage by increasing the density of trichomes (Agarwal 2000). The development of non-glandular trichomes quite earlier than glandular trichomes in the calyx and corolla suggest the protective function to the developing glandular trichomes and other internal structures. As the flower developed, the density decreases in the calyx and they were predominantly centered on the margins. This may be due to gross distension of basal cell and often by raising of surrounding epidermis as proposed by Bini-Maleci *et al.* (1983). High density of trichomes in corolla and stigma of the female flower during maturity suggests their role in effective pollination. According to Corsi and Bottega (1999) non-glandular hairs are involved in mechanical defense and protect the plant from excessive transpiration, reduce heat load of plants, increase tolerance to freezing and deflect intense solar radiation.

Type I non-glandular trichomes were widely distributed in the stigmatic surface, calyx and corolla; whereas Type II non-glandular hairs were distributed in the anther walls and rarely on both the surfaces of corolla. Presence of Type II hairs



in the walls of mature anther may help to attract pollinators and also may serve as pollen presenters, from which pollinators collect numerous pollen grains released from anthers. Presence of pollen presenters on the pistil apex have reported in families like Asteraceae, Campanulaceae, Fabaceae, Rubiaceae, Proteaceae, Lobeliaceae (Howell *et al.* 1993; Matthews *et al.* 1999). Type III trichomes mainly distributed in margins and veins of floral organs and veins of both the surfaces of calyx and corolla, may anchor the flower and protect from external forces. Type IV hairs were distributed in pedicels on developing stage itself whereas their abundance in fully opened corolla reveals its importance in protection.

CONCLUSION

Present study observed that *C. grandis* flowers have a rich diversity in glandular and non-glandular trichomes, varied greatly in morphology, structure and occurrence on reproductive organs. All parts of flower had glandular hairs, they provide mechanical support, Type II hairs in anther and stigma was evident that these hairs have functions in pollination also. Throughout the development, trichomes were covered the floral organs. Non-glandular hairs developed earlier, covered the developing floral whorls as well as developing glandular hairs. Glandular hairs, rather than a mechanical supporting tissue, which secrete oils and other compounds that may provide chemical defense against insects or may help to effective pollination in this species.

ACKNOWLEDGMENTS

Authors are grateful to the Kerala State Council for Science, Technology & Environment for financial support and Head, Department of Botany, University of Kerala for providing facilities.

REFERENCES

- Adedeji, O., Ajuwon, O.Y. and Babawale, O.O. 2007. Foliar epidermal studies, organographic distribution and taxonomic importance of trichomes in the family Solanaceae. *Int. J. Botany*, 3(3): 276-282.
- Agrawal, A.A. 2000. Specificity of induced resistance in wild radish: causes and consequences for two specialist and two generalist caterpillars. *Oikos*, 89(3): 493-500.
- Algan, G. and Bitkisel Dokular, I. 1981. cin Mikroteknik. Firat Univ. Fen-Ed. Fak. Yayın. Bot.1, Istanbul.
- Ascensao, L., Mota, L., De, M. and Castro, M. 1999. Glandular trichomes on the leaves and flowers of *Plectranthus ornatus*: morphology, distribution and histochemistry. *Ann. Bot.*, 84(4): 437-447.
- Baran, P., Ozdemir, C. and Aktaş, K. 2010. Structural investigation of the glandular trichomes of *Salvia argentea*. *Biologia*, 65: 33-38.
- Bini Maleci, L., Corsi, G. and Pagni, A.M. 1983. Trichomes tecteurs et secreteurs dans la sauge (*Salvia officinalis* L.). *Plantes meUdicinales et phytotheUrapie*, 17: 4-17.
- Bisio, A., Corallo, A., Gastaldo, P., Romussi, G., Ciarallo, G., Fontana, N., De Tommasi, N. and Profumo, P. 1999. Glandular trichomes and secreted material in *Salvia blepharophylla* Brandegees ex Epling grown in Italy. *Ann. Bot.*, 83(4): 441-452.
- Bruni, A. and Modenesi, P. 1983. Development, oil storage and dehiscence of peltate trichomes in *Thymus vulgaris* (Lamiaceae). *Nord. J. of Bot.*, 3: 245-251.
- Corsi, G. and Bottega, S. 1999. Glandular Hairs of *Salvia officinalis*: New Data on Morphology, Localization and Histochemistry in Relation to Function. *Ann. Bot.*, 84: 657-664.
- Fahn, A. 1988. Secretory tissues in plants. *New Phytol.*, 108(3): 229-257.
- Goncalves, Letícia de Almeida, Azevedo, Aristéa Alves, Otoni, Wagner Campos, 2010. Caracterização e ontogenia dos tricomas glandulares de *Ocimum selloi* Benth. - Lamiaceae. *Acta Bot. Brasilica*, 24(4): 909-915.
- Haratym, W. and Weryszko-Chmielewska, E. 2014. Structural features of flower trichomes in drug eyebright (*Euphrasia stricta* D. Wolff EX JF Lehm.). *Acta Agrobot.*, 66(4): 35-44.
- Howell, G.J., Slate, A.T. and Knox, R.B. 1993. Secondary pollen presentation in Angiosperms and its biological significance. *Aust. J. Bot.*, 41: 417-438.
- Johanson, D.A. 1981. Plant microtechnique. McGraw-Hill Book Co., New York.
- Kahraman, A., Celep, F. and Dogan, M. 2010. Anatomy, trichome morphology of *Salvia chrysophylla* Stapf (Lamiaceae). *S. Afr. J. Bot.*, 76: 187-195.
- Kennedy, G.G. 2003. Tomato, pests, parasitoids, and predators: tritrophic interactions involving the genus *Lycopersicon*. *Annu. Rev. of Entomol.*, 48: 51-72.
- Kolb, D. and Muller, M. 2004. Light, conventional and environment scanning electron microscopy of the trichomes of *Cucurbita pepo* subsp. *Pepo* var. *styriaca* and histochemistry of glandular secretory products. *Ann. Bot.*, 94(4): 515-526.
- Krings, M., Kellogg, D.W., Hans Kerp and Taylor, T.N. 2003. Trichomes of the seed fern *Blanziopteris praedentata*: implications for plant-insect interactions in the late Carboniferous. *Bot. J. Lin. Soc.*, 141(2): 133-149.
- Lusa, M.G., Cardoso, E.C., Machado, S.R., Appezzato-da-Glo'ria B. 2014. Trichomes related to an unusual method of water retention and protection of the stem apex in an arid zone perennial species. *AoB plants*.



- Mahlberg, P.G. and Kim, E.S. 2004. Accumulation of cannabinoids in glandular trichomes of *Cannabis* (Cannabaceae). *J. of Ind. Hemp.*, **9**: 15-36.
- Mattews, M.L., Gardner, J. and Sedgley, M. 1999. The proteaceous pistil: morphological and anatomical aspects of the pollen presenter and style of eight species across five genera. *Ann. Bot.*, **83**: 385-399.
- Mayer, J.L.S., Carmello-Guerreiro, S.M. and Mazzafera, P. 2013. A functional role for the colleter of coffee flowers. *AoB plants*. 1-13.
- Mota, L., Figueiredo, A.C., Pedro, L.G., Barroso, J.G. and Ascensao, L. 2013. Glandular trichomes, histochemical localization of secretion, and essential oil composition in *Plectranthus grandidentatus* growing in Portugal. *Flavour Fragr. J.*, **28**: 393-401.
- O'Brien, T.P. and McCully, M.E. 1982. The study of plant structure principals and selected methods. Melbourne, Australia: Termocarphy Pty.
- Peterson, R.L. and Vermeer, J. 1984. Histochemistry of trichomes. In: Rodriguez E., Healey PL, Mehta I. (eds). Biology and chemistry of plant trichomes. Plenum Press: New York and London. 71-94.
- Renner Susanne, S., Robert, E. and Ricklefs 1995. Dioecy and its correlates in the flowering plants. *Am. J. Bot.*, 596-606.
- Roy, R.P. 1974. Sex mechanism in higher plants. *J. Indian Bot. Soc.*, **53**: 141-155.
- Tan, J., Walford, S.A., Dennis, E.S. and Llewellyn, D. 2016. Trichomes control flower bud shape by linking together young petals. *Nat. plants*.
- Thanki, Y.J. 1989. Structure and development of hairs in cucurbitaceous fruits. *Feddes Repet.*, **100**: 377-379.
- Tingey, W.M. and Gibson, W.R. 1978. Feeding and mobility of the potato leaf hopper impaired by glandular trichomes of *Solanum berthaultii* and *S. polyadenium*. *J Econ. Entomol.*, **71**: 856-858.
- Wagner, G.J. 1991. Secreting glandular trichomes: more than just hairs. *Plant. Physiol.*, **96**: 675-679.
- Wagner, G.J., Wang, E. and Shepherd, R.W. 2004. New approaches for studying and exploiting on old protuberance, the plant trichomes. *Ann. Bot.*, **93**: 3-11.
- Wang, S., Wang, J.W., Yu, N., Li, C.H., Luo, B., Gou, J.Y., Wang, L.J. and Chen, X.Y. 2004. Control of plant trichome development by a cotton fiber MYB gene. *Plant Cell*, **16**: 2323-2334.
- Werker, E. 1993. Function of essential oil secreting glandular hairs in aromatic plants of the *Lamiaceae* - a review. *Flavour Fragr. J.*, **8**: 249-255.
- Werker, E. 2004. Trichome diversity and development. *Adv. Bot. Res.*, **31**: 1-35.

