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NECTAR GLANDS IN *GOSSYPIUM*

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NECTAR GLANDS IN GOSSYPIUM

FORWORD

Cotton is basically a fibre yielding crop of global significance. Information on nectar glands is not available for ready reference in a single booklet form. The prime objective of publishing the bulletin "Nectar Glands In *Gossypium*" is to fill up this gap. This bulletin provides comprehensive information on various aspects of nectar glands. Hope this bulletin would be of some use to cotton researchers and cotton breeders.

I heartily congratulate Dr. Punit Mohan of CICR, Nagpur for his sincere and untiring efforts in compiling information and bringing out this publication in the shortest possible span of time.

B.M. KHADI

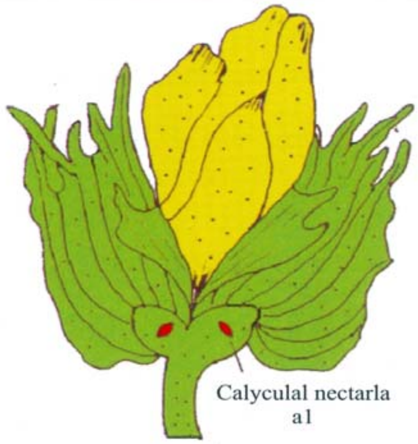
Director

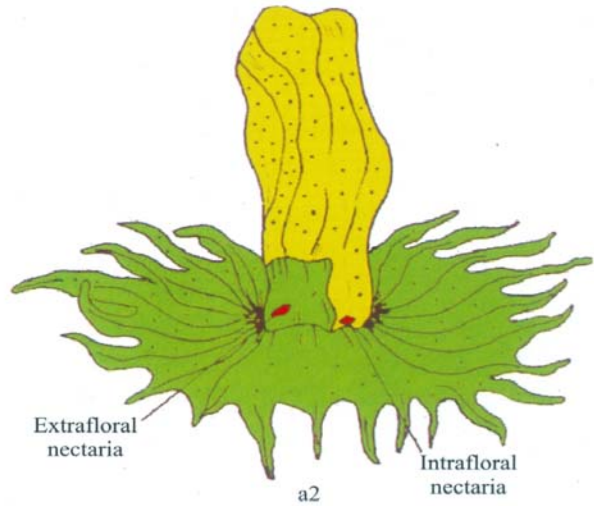
ACKNOWLEDGEMENTS

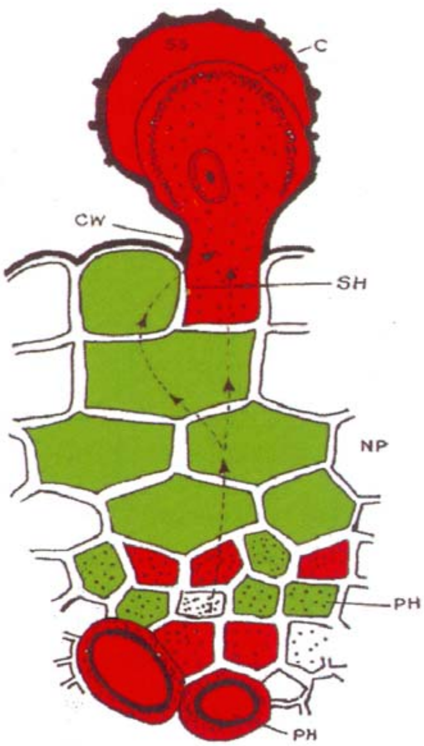
This bulletin has been designed to provide comprehensive information on nectar glands in *Gossypium* species for ready reference of readers. Information contained in this bulletin have been obtained from various scientific and technical sources of National and International relevance.

Author is extremely grateful to Dr. B.M. Khadi, Director, Central Institute for Cotton Research, Nagpur for his constant guidance and encouragement to bring out this publication. The secretarial assistance rendered by Mrs. Rama Iyer and Shri Pramod Titarmare are thankfully acknowledged. I am thankful to Shri P.G. Ghangare for the high quality photographs included in this bulletin. I am also grateful to those who have directly or indirectly helped in preparation of this bulletin.

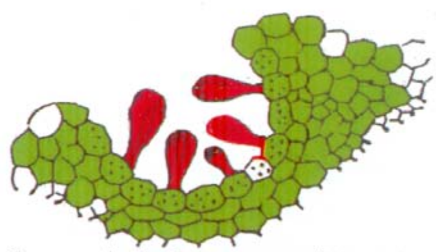
PUNIT MOHAN



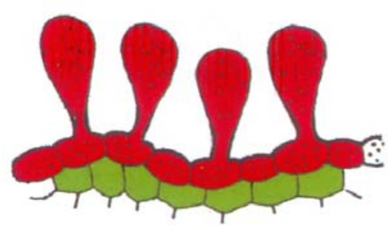




a5: C, cuticle, Ss, subcuticular space; W, cellulose wall-inner layer of wall protuberances; CW, cutinized cell-wall; SH, secretory hair; NP, nectariferous parenchyma; PH, pre-nectar flow from the phloem. (Adopted from A.Fahn, 1979)



a3 : Cross section basin nectary, capitate nectar secreting trichomes



a 4 : Capitate secreting trichomes found on the floor of the crypt nectary

An excellent review on terminology of nectary in various taxon has been presented by many scholars. The term nectary (nectarium) was first coined by Linnaeus (1735) and later clarified by Linnaeus (1751). There has been extensive discussion on these semantic controversies in the literature. Some highlights are briefly presented here.

"Nacterial" is the general term pertaining to nectaries. "Nectariferous" ("nectiferous"), on the other hand, means nectar producing or nectar bearing, whereas "nectareous" ("nectarious", "nectarean" etc.) actually pertains to qualities of nectar. Thus, all cells in a nectary are "nectarial", whether or not they are secretory or "nectariferous".

Nectar secreting tissues and organs have been variously named nectar gland (Candolle, 1827), floral gland (Mirbel, 1809), Sap gland (Sprengel, 1793), Honey gland (Prantl, 1888), Phycosteme (Turpin, 1819), Honey pore (Leppik, 1964, 1977), Nectary (Rao, 1971), Nectarthodes (Sprengel, 1793), Nectar-covers (Sprengel, 1890), Nectar reservoirs (Teuber *et.al*, 1980) or Honey bags (Kerner, 1895). Many of these terms have been much used by both anatomist and taxonomist. Jackson (1928) defined "nectarotheca" as the part of a flower surrounding a nectariferous pore. "Pseudonectaries" or "false nectaries" are not considered as nectaries but rather structures resembling them and thereby deceiving pollinators. (Dafni, 1984; Kunth, 1906; Kugler, 1970).

Nectar gland, nectar holder, nectary disc or disk have general applicability in modem works. The term "Gland" has frequently been used synonymously with "nectary". However, "nectary" is a more preferable term. "Gland" refers to any multicellular secretory structure (Esau 1965, 1977). Delpino (1873) further divided "nuptial" nectaries on the basis of position into "intrafloral", "Circumfloral" and extra floral nectaries.

1. Intrafloral- inside the flower, that is, on receptacles, floral tubes, sepals (adaxially), petals, stamens and pistils.

2. Circumfloral- on the edge (contour) of the flower, that is, on involucra, bracts, bracteols and sepals abaxially.

3. Extrafloral- outside the flower but near its pedicels.

Nectaria in cotton occur both on leaves and flowers. These are distributed on the bottom of leaf blade, their distance from the leaf base being about one-third of the leaf length. Their number, shape and size vary considerably.

1. **Leaf nectaries:** A nectary may not be apparent on the cotyledons, or even on the next three leaves, but subsequently each leaf always bears atleast one. This is to be found on the abaxial surface of the main vein, about one-third of the length of the leaf from the petiole. Later formed leaves have a nectary on the major vein on either side of the midrib,

and some times a pair is also developed on the major veins to the lateral lobe of a leaf, i.e. up to five nectaries on each leaf.

2. **Intrafloral nectaries:** The internal whorl of epicalyx bract nectaries, which occur alternatively on the inner side of the sepal base is narrow thin band covered with glandular, tricellular trichomes (Fig. a2, a3).

3. **Calycular nectaria:** The calycular nectaria are found on the receptacle, near the base of the calyculus (Fig. a 1).

4. **Extra-floral nectaries:** The extrafloral nectaria (l to 3) are found on the receptacle, young peduncles and between the calyculus bracteoles. They are light green, pinkish or bright red in colour and oval, oval angular or irregular in shape (Fig. a2).

Morphoanatomy of nectar glands

Different cotton species and forms exhibit different number of nectaria, this often shows a variation on a plant. The morphology of these nectaries has been studied by several workers (Schwendt, 1907; Janda, 1937), comparison of their structure made between several species (Webber, 1938) and their ontogeny studied in both *Gossypium hirsutum* (Reed, 1917) and *G barbadense* (*brasiliense*) (Schwendt, 1907). Recently the extrafloral nectaries of cotton and their fine structure of secretory papillae were described by Inamdar and Rao (1981) and Eleftheriou and Hall (1983).

Basic anatomical studies of nectaries in various taxon were made in the 19th century by (Behrens, 1879; Bonnier, 1879). Since then, many additional important investigations have been carried out with the aid of light microscope (Bohmker, 1917; Fahn, 1953; Ancibor, 1969; Elias and Gelband, 1976). Nectary may be deeply sunken or in the form of an outgrowth on the surface of an organ, or on an epidermis with or without trichomes, subtended by a specialized parenchyma (Fig. a3, a4) (Fahn, 1974). The parenchyma is generally composed of small cells with thin walls, relatively large nuclei, dense granular cytoplasm and small vacuoles (Caspary, 1848; Behrens, 1879; Bonnier, 1879; Fahn, 1952, 1974). The nectaries either about the regular vascular system of organs on which they occur are connected to it by special vascular tissues (Frei, 1955). Nectar is exuded from the nectary by ordinarily epidermal cells by trichomes (Fig. a3, a4, a5), or by the nectariferous parenchyma cells which secrete into intercellular spaces and from them to the surface via modified stomata. The cells from which the nectar is eliminated are called the secretory cells of the nectary (Fig. a5). In nectaries of some plants, the secretory cells are covered by a relatively thick cuticle and the nectar either rupture the cuticle (Behrens, 1879) or exude through special pore ego In *Abutilon* (Findley and Mercer, 1971).

Mechanism of nectar secretion

The origin of the secreted nectar is the phloem sap (Frey-Wyssling, 1955; Zimmermann, 1953; Matile, 1956). The pre-nectar moves from the sieve elements to the cells of the nectariferous tissue. The factors governing the preferential movement of the pre-nectar towards the secretory cells rather than other neighbouring cells are not yet clear, though it has been suggested that there is a sugar concentrating mechanism in a nectariferous tissue, as a result of which a water potential gradient is established which brings about a flow (Luttge and Schnepf, 1976) (Fig. a5). The composition of the prenectar may become modified in the nectariferous tissue by enzymatic activity and by the process of reabsorption (Luttge 1961; Ziegler, 1965).

Various suggestions have been made concerning the mechanism of nectar secretion. There are theories of active molecular transport though membranes (Luttge and Schnepf, 1976) or via vesicles whose membrane fuse with the plasmalemma.

Origin of nectar and activity of nectar gland

"Nectar" is in liquid form secreted by nectaries. The old literature frequently employs sap honey juice or especially "honey" in place of "nectar" (Sprengel, 1793). Honey, incidentally, is derived from the raw materials - nectar and honey dew, both of which are commonly collected by bees and also directly from phloem sap (Maurizio, 1962).

Chemical composition of nectar was analysed in various taxon. Nectar consist of amino acids, sugars and small amount of other materials (Fahn, 1949; Baker and Baker, 1975; Hanny and Elmore, 1974). Baker *et. al.*(1978) analysed the composition of the phloem exudate and the nectar exuded from the extra floral nectaries. The secreted nectar contained considerable quantities of fructose and glucose, whereas, in the phloem exudate sucrose was the only sugar present and the amounts organic substances other than sugars were lower in the nectar than in the phloem exudate.

Trelease (1879) observed that the first three leaves of a seedling do not produce an exudate from their nectaries. Observations at five hourly intervals during the night failed to support another conclusion of Trelease that cotton leaf nectaries secrete mainly at night. An attempt was made to affect the secretory activity of these nectaries in as series of experiments in which the stem or petioles were bark ringed (Mason and Maskell, 1928). No increase or decrease in the nectary secretions was observed on any of the plants tested during the two days following ringing. Tayler (1908) has reported that floral nectar is secreted only on the day of anthesis, but extra floral nectaries continue to secrete nectar for several days. However, Butler *et. al.* (1972) have reported variability in quantity of nectar production at different intervals of hour in the genotypes of *G.hirsutum* and *G barbadense*. Mound (1962) reported that Whitefly attack in *Gossypium* increased the secretory activity of the nectaries, particularly at the higher levels of infestation. Jassid also had a marked effect, but at a lower level. Thrips did not cause any obvious increase in the amount of exudate.

Vansell (1944a) analysed the composition of floral nectars and their corresponding honey. Mound (1962) reported on the extrafloral nectaries of cotton and used chromatograms to evaluate the composition of the secretions. Kaziev (1964) published a comprehensive summary dealing with the production of nectary by the cotton plant in which he described the structure of the nectaries, and influence of soil, climatic conditions and agricultural techniques on the secretion of nectar. Vansell (1944b) and Kaziev (1964) reported that the primary sugars of cotton nectar were glucose, fructose and sucrose, with glucose and fructose predominating.

Geneties of nectariless character:

The genetics of nectariless character has been reviewed by Leak and Ram Prasad, 1914; Kottur, 1923; Hutchinson and Silow 1939; Sethi *et. al.* 1960. Nectariless character in cotton is controlled by monogenic recessive gene "ne". According to Nile (1980) the nectariless trait in cotton is controlled by two pairs of recessive ne1 and ne2 genes. As such, recessive genes are responsible for bollworm resistance in nectariless cotton.

However, Leak (1911) reported a mutant in the Asiatic cottons that had no leaf nectaries. *Gossypium tomentosum* is unique among cottons in that it is devoid of leaf and extrafloral nectaries (nectariless). Meyer and Meyer (1961) transferred the nectariless character to *G.hirsutum* and determined that duplicate recessive, ne_1 ne_2 control the expression. Holder *et. al.* (1968) established that ne_1 and ne_2 were linked to $g1_2$ and gl_3 respectively, and formed homologous linkage groups. The mutant genes are not completely recessive and segregation at the Ne_1 or Ne_2 loci can be determined primiarly in test cross, by the size and number of absence of nectaries on the leaves and flowers (Holder *et. al.*, 1968).

Nectaries and insect activity in Gossypium:

The importance of cotton nectar and its influence on some pests of cotton has been recognized for many years. Trelease (1879) observed that during the night extrafloral nectaries were visited by several months of *Alabama argillacea* (Hubner) and *Heliothis armigera* (Hubner). Lukefahr and Rhyne (1960) found that population of *Alabama argillacea* and *Trichoplusia ni* (Hubner) were 7 to 10 times higher on cotton with extrafloral nectaries than on a selection of cotton that did not have them. Butler (1968) reported that sugars in the form of honey dew or nectar greatly improved the survival of *Lygus hesperus* Knight on alfalfa. Adult lygus bugs were attracted to cotton sprayed with sugar or honey. Survival of both adults and nymphs was improved when either sugar or honey was present, and survival of nymphs on buds, flowers and bolls was highest on those forms that had active extrafloral nectaries. Ingestion of extrafloral nectar could be an important factor in increasing the energy reserves and survival of the boll weevil, *Anthonomus grandis* Boheman. Trelease (1879) also recognized the important of extrafloral nectar in attracting, maintaining, and dispersing predaceous insects over the plant.

Stith (1970) reported that honey bees, *Apis mellifera* provided cross pollination for hybrid seed production. Higher population of honey bee will be more beneficial for hybrid seed production (Deshmukh *et.al.*, 1995; Bhale and Bhat, 1989, 1998; Bhale *et. al.* 1989; Putin Mohan and Kairon, 1999). However, differences in the varietal attractiveness of floral nectar to honey bees is known to occur (Kaziev, 1964; Stith, 1970; Vansell, 1944 b) and may contribute to selective cross pollination. Therefore, more complete information on cotton is needed for utilizing honey bee as a pollinator in hybrid seed production.

In nectariless varieties, leaves and floral parts are devoid of nectar glands. As a result, such plants are visited less frequently by honey bees and moths than the normal plants (Moffet *et. al.* 1975). Nectariless trait reduced insect species from 87 to 23 in USA and did not show any adverse effect in plant growth and development (Jenkins, 1989). Glabrous and nectariless trait provide effective resistance to bollworms (Wilson and Wilson, 1976). Nectariless character i.e.

absence of nectaries in leaf and flower in cotton is another important character reported to be associated with bollworm resistance (Lukefahr *et. al.* 1971; Lukefahr and Martin, 1966; Devis, 1969 and Davis *et. al.* 1973).

Lukefahr and Griffin (1956) reported that sugar was necessary as a food to increase oviposition in case of pink bollworm moths. According to Lukefahr and Martin (1966), absence of nectaries reduced food for the moths and both *Heliothis zea* and *H. virescens* oviposited fewer eggs in cotton when no food was available. Lukefahr *et. al*. (1965) found out that oviposition by moths of American bollworm *Heliothis zea* and tobacco budworm *Heliothis virescens* was reduced from 30 to 60 per cent in a nectariless cotton variety and mines formed by pink bollworm (*Pectinophora gossypiella*) larvae were reduced by 50 per cent in the boll of nectariless cotton variety. The field cage test study conducted by Lukefahr *et. al.*, (1965, 1966) showed that the oviposition of moths of H. *zea* and H. *virescens* was significantly reduced in nectariless cotton.

Infestation by pink bollworm was lower in nectariless cottons as reported by Davis *et. al.* (1973). But Lukefahr and Rhyne (1960) found that the presence or absence of nectaries on the cotton plant did not affect pink bollworm population. Narayanan *et.al.* (1988) and Narayanan (1991) have presented an excellent review of various morphological attributes and insect resistance breeding with particular reference to *Heliothis* and other serious pests in cotton. The mechanism of resistance to bollworm complex in nectariless cotton as non feeding and non preference to ovipositon by moths of bollworms has been reviewed by various workers (Narayanan *et. al.* 1988, Narayanan and Jayaswal, 1984; Jayaswal and Ram Ratan, 1988; Kadapa *et. al.*, 1983; Basu, 1988; Kadapa, 1988; Shroff and Mandloi, 1988; Agarwal and Katiyar, 1974; Maxwell *et. al.* 1988).

A most convincing large scale population study over a period of four years with 29 experiments was made by Davis *et. al.* (1973). They reported development of nectariless Acala 1517 D and other nectariless agronomic cotton varieties. In the first eight experiments, nectaries vs nectariless isogenic lines were investigated by growing more than 4500 plants of each genotype in the same environment. It was shown that 50 per cent less number of eggs were laid on the nectariless isogenic line as compared to 1,82,620 eggs laid on nectaried line of the same variety. In another study reported by Davis in the same paper, nectariless glabrous lines were compared with nectaried hairy isogenic lines. The combibed effect of glabrous nectariless characters was more pronounced in reducing the number of eggs laid than effect of these characters individually. The number of eggs laid by *Heliothis* were 45 percent less on nectariless-hairy line vis-a-vis 68 percent less on nectariless glabrous isoline of Acala 1517 D. Hedin *et. al.*, 1974; Zur *et. al.* 1979 and Noble, 1969 also reported that absence of extrafloral nectaries adversely limit the longevity and fecundity of *Heliothis* sp. and pink bollworm. Schuster *et. al.* (1976) noticed significant reduction of different insect populations in cotton plants without extrafloral nectaries.

Maxwell *et. al.* (1976), Belcher *et. al.* (1984) and Lima *et. al.* (1984) demonstrated non-preference of *Heliothis* spp. for nectariless cottons. Knowledge of the preferred sites of ovipositon will help in breeding for modification of the sites which will be disadvantageous for ovipositon. Since the most preferred sites of *Heliothis* and *Pectinophora* bollworms are leaves and base of bracteoles respectively.

To investigate the role of individual characters on bollworm incidence, isogenic lines with JK 97 background were created by Kadapa (1980). It was found from his study that combination of characters rather than one character are more useful in imparting tolerance to bollworms.

From the foregoing information, it is obvious that nectaries in cotton can be considered as the most important morphological attribute which needs thorough investigation. Further studies on aspects relating to shape, size and variation in nectar glands and composition of nectar (sugars, amino acid content, etc.) besides recessive/ dominance relationships, pattern of inheritance and anatomical details would help to bring out a more clear picture which would help cotton breeders in formulating a more elaborate breeding programme with scope to evolve a desirable genotype.

Gossypium hirsutum

Sr. No.	Name of Accessions	Leaf Nectar Glands
1.	AET 5 N (NL, H)	ABSENT
2.	AET 5 NS (NL, G)	ABSENT
3.	AET 5 NL (NL, O, H)	ABSENT
4.	AET 5 ne H N (NL, H)	ABSENT
5.	AET 5 ne Sa2 Lo (NL, O, G)	ABSENT
6.	AET 5 ne H Lo (NL, O, H)	ABSENT
7.	Auburn ne 213 SPB+OPB (NL, H)	ABSENT
8.	CMS-S 278 N (g) (NL, H)	ABSENT
9.	DES 24-B ne (NL, H)	ABSENT
10.	DES 146A (Restorer) (GL, NL, G)	ABSENT
11.	GP 189 A (NL, G)	ABSENT
12.	ST Smooth Nectariless (NL, G)	ABSENT
13.	Super Okra ne CMS x Demeter (III) Fl BA (NL, SO, G)	ABSENT
14.	Super Okra ne CMS x Demeter (III) Fl BB (NL, SO, G)	ABSENT
15.	Super Okra ne CMS x Demeter (III) Fl (IV) B (NL, SO, G)	ABSENT
16.	TXCAMO 21-5-1-78 (F, NL, O, P, G)	ABSENT
17.	24-B (Nectariless) (NL,G)	ABSENT
18.	138 F(B) (NL, H)	ABSENT
19.	JK 97 FNR (F, P, H)	ABSENT
20.	JK 97 FORN (F, NL, O, P, G)	ABSENT

21.	JK 97 FBRN (F, NL, P, H)	ABSENT
22.	JK 97 NOGN (NL, O, G)	ABSENT
23.	JK 97 NOPRN (NL, O, P, G)	ABSENT
24.	JK 97 FNOPR (F, NL, O, P, H)	ABSENT
25.	Q-22-4-84 x 4669- (GL, NL, H) (TIL-20R)	ABSENT
26.	N-B-15-85 x T3L-19L- (NL, P, H) (E20-7)	ABSENT
27.	Nectariless (NL, G)	ABSENT
28.	Buri Nectariless (NL, DH)	ABSENT
29.	TXCAMO 21-5-1-78- (F, NL, O, P, G) SP 12	ABSENT
30.	TXCAMO 21-5-1-78- (F, NL, O, P, H) SP 16	ABSENT
31.	ne CMS x Demeter (III) - (NL, G) F1-(II) AY	ABSENT
32.	American Nectariless (NL, G)	ABSENT
33.	Super Okra Ne Hairy- (NL, SO, DH) SP 3	ABSENT
34.	Green EC 677 (F, NL, P, G)	ABSENT
35.	WC-12 NL (T88/202) (O, NL, G)	ABSENT
36.	WC-11 NSSL (T88/207) (O, NL, G)	ABSENT
37.	WC-1- NL (T88/206) (O, NL)	ABSENT
38.	GP 284 (G, NL, F)	ABSENT
39.	GP 285 (NL, F)	ABSENT
40.	GP 283 (NL, F)	ABSENT
41.	GP 282 (NL, F)	ABSENT
42.	GP 278 (NL, F)	ABSENT
43.	GP 281 (G, NL, F)	ABSENT
44.	GP 280 (NL, F)	ABSENT
45.	GP 285 (GL, NL, F)	ABSENT

Gossypium arboreum

Sr. No.	Name of Accessions	Leaf Nectar Glands
1.	Lohit (NL, PH)	ABSENT
2.	Chinese Spotless (NL, P, H, PSA)	ABSENT
3.	G 153 (NL, H)	ABSENT
4.	LD 135 (NL, H)	ABSENT
5.	Naked Seed (NL, NS, H)	ABSENT

6.	Malvensis (CN, NL, G)	ABSENT
7.	Cocanada 5 (NL, G)	ABSENT
8.	Cocanada 20 (NL, H)	ABSENT
9.	LD 327 (NL, P, H)	ABSENT
10.	79/Lohit (NL, P, H)	ABSENT
11.	AC 36 (NL, P, H)	ABSENT
12.	Chandrolla (NL, P, H)	ABSENT
13.	G 27-51 (NL, P, G)	ABSENT
14.	Mudhol 2927 (NL, P, H)	ABSENT
15.	Sanguineum / G 26 (NL, P, H)	ABSENT
16.	Sanguineum / G 27 (NL, P, H)	ABSENT
17.	Sanguineum /Minor (NL, P, G)	ABSENT
18.	IC 377/8 (NL, P, H)	ABSENT
19.	79/BH 47 (NL, P, H)	ABSENT
20.	79/BH 53 (NL, P, H)	ABSENT
21.	P 642 BLL (NL, P, H)	ABSENT
22.	P 642 NLL (NL, P, DH)	ABSENT
23.	P 562 BLL (NL, P, H)	ABSENT
24.	P 562 NLL (NL, P, H)	ABSENT
25.	P 559 A (NL, P, H)	ABSENT
26.	P 511 (NL, P, H)	ABSENT
27.	P 560 BLL (P, NL)	ABSENT
28.	P 560 NLL (P, NL)	ABSENT
29.	K 4014 (NL, P, HO)	ABSENT
30.	AC 3290 (NL, P, H)	ABSENT
31.	AC 3503 (NL, P, H)	ABSENT
32.	AC 3088 (NL, P, H)	ABSENT
33.	AC 3051 (NL, P, DH)	ABSENT
34.	AC 3451 (NL, P, H)	ABSENT
35.	AC 3161 (NL, P, H)	ABSENT
36.	AC 3175 (NL, P, H)	ABSENT
37.	AC 3149 (NL, P, H)	ABSENT
38.	AC 3354 (NL, P, H)	ABSENT
39.	AC 3271 (NL, P, H)	ABSENT
40.	AC 3722 (NL, P, DH)	ABSENT
41.	AC 3546 (NL, P, H)	ABSENT
42.	AC 3725 (NL, P, H)	ABSENT
43.	AC 3052 (NL, P, H)	ABSENT
44.	AC 3073 (NL, P, H)	ABSENT
45.	AC 3494 (NL, P, H)	ABSENT

46.	AC 3400 (NL, P, H)	ABSENT
47.	AC 3475 (NL, P, H)	ABSENT
48.	AC 3709 (NL, P, H)	ABSENT
49.	AC 3379 (NL, P, H)	ABSENT
50.	AC 3422 B (NL, P, DH)	ABSENT

Gossypium herbaceum

Sr. No.	Name of Accessions	Leaf Nectar Glands
1.	E 2-18-19 B (TP 84) (CL, NL, H)	ABSENT
2.	E 2-18-19 W (TP 84) (NL, H)	ABSENT
3.	E 2-18-19 LB (TP 84) (CL, NL, H)	ABSENT
4.	R 51-5-105 (NL, DH)	ABSENT
5.	R 51-238 (NL, DH)	ABSENT
6.	72-34 (NL, DH)	ABSENT

Range of variability in Size of Nectar Glands

Gossypium hirsutum

Sr. No.	Name of Germplasm Accessions	Floral Nectar Gland Cavity Size(μ)
1.	H.19	413.29
2.	CPD 8-1	398.11
3.	BURI.147	405.23
4.	BOBSHAW	411.28
5.	LH.900	400.17
6.	F.414	387.15
7.	UPA.57-7	413.71
8.	VIKRAM	409.23
9.	MALKOV	391.10
10.	MILLER.45-9	428.29
11.	ABADHITA	443.57
12.	KAPLAND	450.11
13.	TEXAS-56	398.79

14.	COKER.413-68	411.55
15.	HAMPI	383.17
16.	CNH 36	419.53
17.	TASHKENT-3	368.17
18.	PUSA-501	400.21
19.	ACALA HOPI.76-15	459.63
20.	PUSA.63	377.21
21.	PRAMUKH	442.23
22.	TEXAS-63	370.51
23.	MCU.10	400.33
24.	VIKAS	451.10
25.	BARBARTON	438.14
	Range	368.17 - 459.63

Range of variability in Size of Nectar Glands

Gossypium arboreum

Sr. No.	Name of Germplasm Accessions	Floral Nectar Gland Cavity Size (µ)
1.	ARVENSIS	305.28
2.	CHINESE NEW MILLION DOLLAR	318.23
3.	LS-I	255.11
4.	AC 3263	269.27
5.	BANILLA FAINT SPOT	329.57
6.	LD 153	293.11
7.	VIRNAR	288.23
8.	GHOST SPOT	305.11
9.	MALVENSIS	272.23
10.	CERNUUM	280.29
11.	COCANADA-2	301.55
12.	BISNOOR	223.29
13.	BURMA SILK	329.11
14.	ADONICUM	300.55
15.	ABUHARIA	268.29

16.	Y-I	271.11
17.	GARO HILL (RF)	301.28
18.	DHULIA-215	217.11
19.	COMILLA	269.58
20.	CHANDROLLA	300.11
21.	MUDHOL 3394	291.23
22.	C 520	255.28
23.	ROSI-8	273.11
24.	LOHIT CAK-79	301.43
25.	COCANADA-5	298.91
	Range	217.11 - 329.57

Range of variability in Size of Nectar Glands

Gossypium herbaceum

Sr. No.	Name of Germplasm Accessions	Floral Nectar Gland Cavity Size (µ)
1.	VIJALPA 2080	253.11
2.	WAGOTAR	272.23
3.	RAICHUR-51	297.88
4.	BHARUCH-9	305.11
5.	SUYODHAR	299.28
6.	WAGAD-8	265.11
7.	VIJAY	302.05
8.	RUSSIAN-19	229.53
9.	DB.3-12	298.27
10.	SUJAY	301.42
11.	G Cot. 13	263.11
12.	DIGVIJAY	240.35
13.	DHARWAD-I (D-I)	300.28
14.	JAYWANT	268.71
15.	WESTERN-I	291.68
16.	SM.88	290.55
17.	BALUCHISTAN.7	301.48

18.	SUYOG	255.43
19.	WESTERN TALL	305.71
20.	RUSSIAN-5	300.58
21.	KFT-I	291.11
22.	BALUCHISTAN-I	300.19
23.	RK-19	271.22
24.	SURTI BHARUCH-I	290.57
25.	KALAGIN	268.79
	Range	229.53 - 305.71

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