UNIVERSITY OF RAJASTHAN
STUDIES
IN
BOTANY

JAIPUR
1965

CONTENTS

THE FLOWER AND THE GAMETOPHYTES OF *HOPPEA DICHOTOMA* WILLD

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The family Gentianaceae to which *Hoppea* belongs can be easily distinguished from other families of sympetalae due to the presence of opposite leaves, actinomorphic flowers and unilocular ovary with two parietal placentae. Nevertheless, it has been variously placed by taxonomists in their systems of classification (Bentham & Hooker, 1876 ; Engler & Prantl 1897 ; Hutchinson, 1920). The present work deals with the flower and the male and female gametophytes of *Hoppea dichotoma*, while the Endosperm and the Embryogen have already been described by Govindappa (1961)

Material and Methods :

Material for this study was collected from Ajmer and fixed in Formalin-acetic-alcohol. Usual methods of dehydration, clearing and embedding were followed through butyl alcohol series. The gametophytes were studied in transverse sections, cut at 7 to 13 microns. Sections were stained in Heidenhains-iron-alum-haematoxylin using orange-G in clove oil as counter stain.

The flower microsporogenesis and the male gametophyte.

The anther wall consists of four layers-epidermis, endothecium, a middle layer and tapetum (Fig. 16). The glandular tapetum at the microsporocyte stage is fully developed. Its cells are uninucleate and possess nonvacuolated cytoplasm around the large nuclei. The tapetal cells, however, become highly vacuolated at the microspore stage and their remnants are left behind at maturity of the pollen-grains (Fig. 16). The middle layer is absorbed during the development of the pollen grains and it disappears at the maturity of the anther. The endothecium develops radial bands of fiberous thickenings on its walls at the uninucleate pollen grain stage. These thickenings, however, become very conspicuous at the maturity of the pollen grains (Fig. 16). At shedding stage the pollen grain is bicelled but in some cases generative-cell may undergo division before the pollen is shed (Fig. 14). All the stages of meiosis may be available in the same anther. In one loculus were seen the 1st and 2nd divisions of meiosis. As seen in a transverse section the anther loculus contains compactly arranged and deeply staining microspore mother cells. These round up and develop a mucilage sheath around their protoplast (Fig. 4). The nuclear divisions of microsporocytes are of the simultaneous type (Figs. 5-8). No wall is laid down between the two daughter nuclei at the conclusion meiosis I. However, after meiosis II, wall formation occurs resulting in tetrahedral, decussate and isobilateral tetrads (Figs. 9, 10) ; the first being of common occurrence.

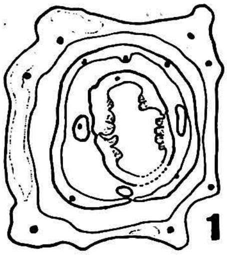
Uninucleate microspores develop a thin memberane as soon as they separate from the tetrads; this is followed by an intine and a characterstic exine. The microspore enlarges and its exine become ornamented (Fig. 11). The nucleus of the microspore divides while at the periphery (Fig. 12) resulting in a bicelled pollen grain (Fig. 13). Pollen grains germinate on the stigma (Fig. 15).

Flower :

Flowers are borne in whitish yellow dichasial cymes. They are small, pedicellate bracteate and tetramerous. The calyx consists of four sepals overtoping the four tips of the campanulate corolla. One fertile stamen and three rudimentary staminodes are epipetalous on the corolla tube (Figs. 1, 2). The filament of the fertile stamen is flattend at the base, bearing a basifixed four celled anther (Fig. 2). Gynoecium is bicarpellary syncarpous and superior. The ovary is unilocular with two glandular placentae, each distinctly divided into two (Fig. 1). A similar condition occurs in the Orobanchaceae although placentae are massive and T-shaped (Tiagi, 1951). The placentae in *Hoppea* on the other hand are thin and spread out on the larger inner lateral surface of the ovary wall (Fig. 3). The style is simple and stigma sub entire; bifid in young flowers (Fig. 2).

Ovule, megasporogenesis and the female gametophyte :

The anatropous unitegmic and tenuinucellate ovules arise as swollen protuberances on the placenta. They are arranged in a few rows on the carpellary margins (Figs. 1, 3). The tissue lining the locule is richly protoplasmic as reported in *Oblaria* (Lindsey, 1940) The single layered nucellus disintegrates during the development of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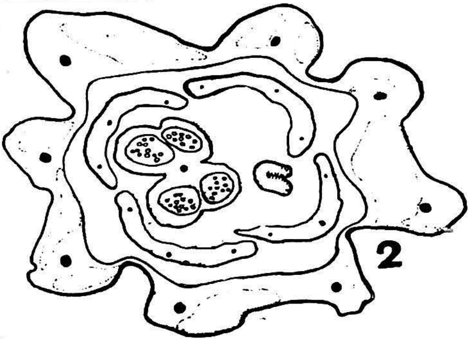
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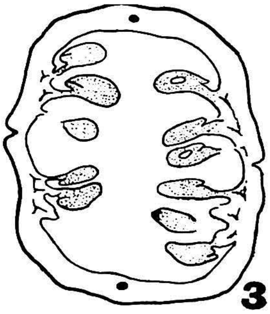
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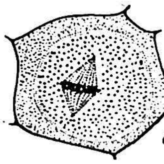
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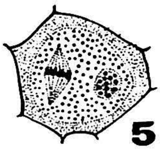
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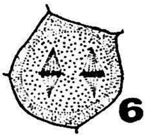
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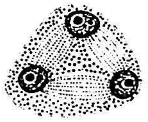
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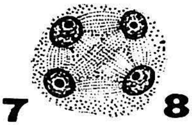
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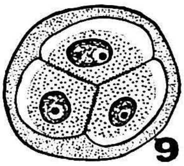
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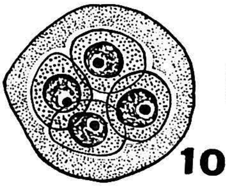
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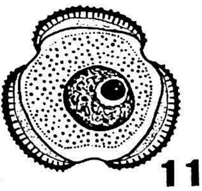
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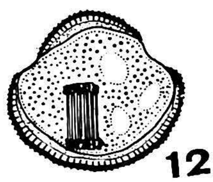
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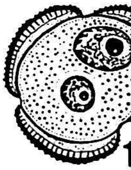
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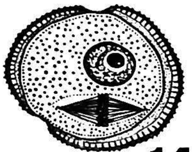
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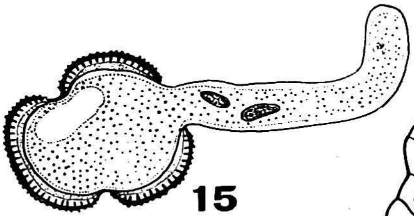
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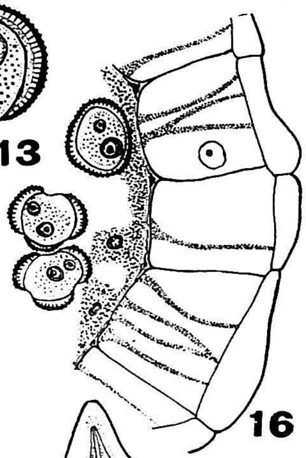
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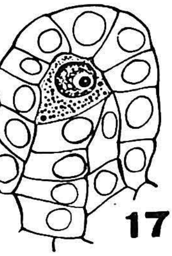
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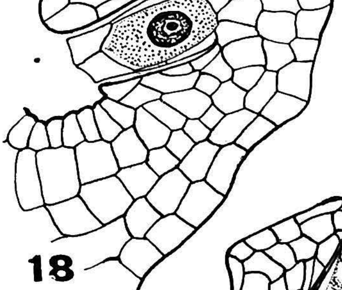
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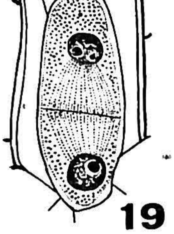
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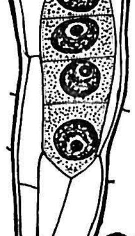
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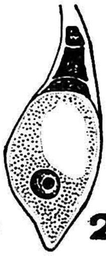
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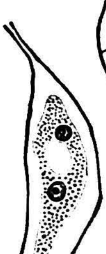
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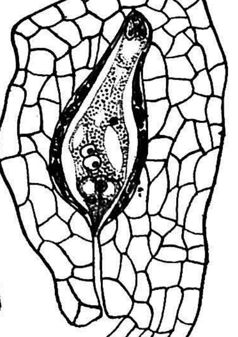
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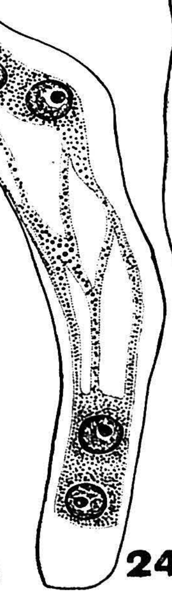
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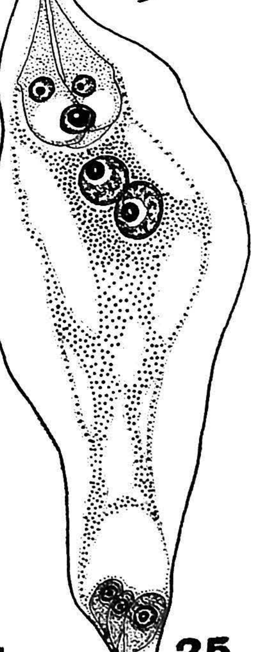
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the embryo sac. A feeble and inconspicuous integumentary tapetum appears to be organised around the embryo sac (Fig. 23) although Govindappa (1961) reports its absence in his material. The micropyle is long, straight and conspicuous.

The archesporial cell is differentiated rather early in the ovular primordium and it directly functions as the megaspore mother cell (Figs. 17, 18). The megaspore mother cell undergoes meiotic divisions giving rise to dyad (Fig. 19) and linear tetrad of megaspores (Fig. 20). The chalazal functioning megaspore enlarges and becomes vacuolated (Fig. 21). By three successive divisions it forms the eight-nucleate Polygonum type of embryo sac (Figs. 22–25). The mature embryo sac penetrates into the chalaza almost touching the ovular hypodermis. (Fig. 23). The egg-apparatus consists of two beaked and hooked synergids and a centrally placed egg. The two large polar nuclei lie close together near the egg-apparatus in the broader part of the embryo sac. The three antipodal cells like the synergids are pear shaped in appearance. Their pointed ends are directed towards the chalaza. It appears that they play some significant role in the nutrition of the embryo sac.

SUMMARY

The flowers are tetramerous. There is one fertile stamen and three staminodes. Gynoecium is bicarpellary and unilocular. Although thin and spread out, the glandular placentae are like those of the Orobanchaceae.

The tapetum is glandular and its cells are uninucleate. Divisions of microspore mother cells are of the simultaneous type resulting into tetrahedral and decussate tetrads of microspores. The exine of the pollen grain is ornamented and at the shedding stage it is bicelled.

Ovule is anatropous, unitegmic and tenuinucellate. The nucellar epidermis degenerates and feeble integumentary tapetum develops from the innermost layer of the integument. The archesporial cell functions directly as the megaspore mother cell. The embryo sac is of the Polygonum type. The antipodals are pear-shaped and they appear to play some significant role in the nutrition of the embryo sac.

Acknowledgements :

I am thankful to Dr. B. Tiagi for helping me in the preparation of this work.

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Fig. 1-25. *Hoppea dichotoma* :—The flower and the gametophytes. (Male Figs. 1–16, Female, Figs. 17–25) Fig. 1. T. S., Flower bud. Fig. 2. Same, showing anther. Fig. 3. T. S., Ovary. Figs. 4–8. Meiosis I and II. Fig. 9. Tetrahedral tetrad. Fig. 10. Decussate tetrad. Fig. 11. Pollen grain, one celled. Fig. 12. Same, dividing. Fig. 13. Same, bicelled. Fig. 14. Same, generative cell dividing. Fig. 15. Same, germinating. Fig. 16. T. S., portion of anther, note thickenings in endothecium and bicelled pollen grains. Fig. 17. Archesporial cell. Fig. 18. Ovule, megaspore mother cell. Fig. 19. Dyad. Fig. 20. Linear tetrad. Fig. 21. Same, functioning megaspore. Fig. 22. Embryo sac, two nucleate. Fig. 23. Ovule, mature embryo sac. Fig. 24. Embryo sac, four nucleate Fig. 25. Same, eight nucleate. (Figs. 1–3 X40; Figs. 4–10, 17, 19–22, 24 and 25. X671; Figs. 11–15 X1143; Fig. 16, X543; Fig. 18, X443 Fig. 23, X275).

FLORAL MORPHOLOGY AND VASCULAR ANATOMY OF *CUSCUTA HYALINA* ROTH, AND *C. CHINENSIS* LAMK.

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The dodders, as the species of *Cuscuta* are often called, are leafless, twining, herbaceous, total stem-parasites of the angiosperms. An interesting exception, however, is a species of *Equisetum* which was found to be attacked by *Cuscuta reflexa* (Sen, 1959). Many dodders are annual but some are perennial, possessing interesting contrivances for tiding over unfavourable periods. According to Rao (1938) the haustorial tissue may persist in the body of the host, giving rise to young shoots early in the following growing season. Truscott (1958) has also shown that new shoots can regenerate from dodder-haustoria. *Cuscuta epithymum* forms hibernating tubercles on the stems of the host and much of the localised spreading of the parasite is due to the vegetative growth from these tubercles (Shillito, 1952). Dean (1954) observed that the dodders may over-winter as haustorial tissue within the galls induced by the parasite. Vegetative hibernation of *C. epithymum* is widespread and it takes place at a depth of one to two cms. below the soil (Stojanvic 1959).

Narayana (1956) observed a diffuse type of parasitism in *Cuscuta hyalina.* He found it parasitic on 42 species, belonging to 35 genera and 16 families of the angiosperms. Depending on the preference of the parasite, there are some principal hosts, while others are secondary or even tertiary. Grasses and sedges are regarded as minor hosts since they are poorly attacked and just help the parasite in crossing over from one suitable host to another. Earlier, Sheriar (1951) reported that dodder first attacks a suitable host and then spreads to other hosts. Vasantharaj (1959) reports *Cuscuta hyalina* on 12 common weeds especially *Tribulus terrestris.* According to Chavan and Sabnis (1960) *Cuscuta hyalina* and *C. chi-*

nensis are parasitie on herbaceous plants. Their parasitism is of the cosmopolitan or the diffuse type. They found *C. chinensis* causing havoc on the crop of lucerne in Baroda.

Hooker (1885) records 7 species of *Cuscuta* for India, *C. reflexa* and *C.gigantea*, under the subgenus Monogynella; *C. hyalina*, *C. chinensis*, *C. capitata*, *C. europea*, and *C. planiflora*, under the subgenus Eucuscuta. Recently Banerji & Das described a new species of *Cuscuta* from Nepal. Santapau and Patel (1957) reported *C. reflexa*, *C. hyalina*, *C. australis* and *C. chinensis*, as occurring in Bombay.

Embryology of the genus *Cuscuta* is fairly well known (Fedortschuk, 1951; Smith, 1934; Tiagi, 1951; Johri & Tiagi, 1952) but very little is known about its floral morphology (Santapau & Patel, 1957) and vascular anatomy. An attempt has been made therefore, to present an account of the floral morphology and vascular anatomy of *C. hyalina* and *C. chinensis.*

Material and Method

The material of *Cuscuta hyalina* and *C. chinensis* was collected from Ajmer, during rainy season. The former was parasitic on *Tribulus terrestris*, and the latter on *Achyranthes aspera.* The buds and the flowers were processed through alcohol xylol series for embedding in paraffin wax. Sections cut at 10 to 15 microns were stained in crystal violet and erythrosin.

Observations

The flower :

The bracteate flowers are small, whitish in *C. chinensis,* and yellowish in *C. hyalina*, shortly pedicellate, in lateral clusters. They are pentamerous, but tetramerous flowers are quite common in *C. hyalina.* There are five unequal sepals which are fused at their bases. The sepals are ovate, acuminate in *C. hyalina*, and triangular, deltoid, tuberculated and clearly carinate in *C. chinensis*. The corolla tube is made up of five petals. The corolla lobes are long, acuminate in *C. hyalina* : ovate-oblong in *C. chinensis*. Staminal scales are absent in *C. hyalina*; present in *C. chinensis*, reaching upto the stamens, oblong, truncated, and almost bifid with many fimbriations. The five anthers are inserted at the throat of the corolla tube, and they are somewhat exserted. The ovary is imperfectly two celled with two ovules in each loculus. There are two elongated slender, unequal styles bearing capitate glandular stigmas.

The thalamus and the sepaline supply :

The thalamus is almost triangular in outline in *Cuscuta chinensis* (Fig. 5); rounded in *C. hyalina* (Fig. 8). The cortex is made up of large parenchymatous cells. The cells surrounding the stele and those of the pith are laden with starch. There are about six to ten discrete, collateral and radially elongated bundles in the stele (Fig. 5). Phloem is in abundance while the xylem is rather weakly developed. Some of the feeble traces and bundles may even consist entirely of phloem. Gum cells occur in the cortex, in between the vascular bundles, and even within the phloem. In *C. hyalina* however, these cells are mostly confined to the hypodermal region of the cortex (Fig. 8). The stele gives out traces, one for each of the sepals (Figs 6–8). As the sepaline traces arise, the pith becomes prosenchymatous (Figs. 6, 8) and the thickenings extend to the inner epidermis of the sepals (Figs. 10–12). After the differentiation of the sepaline ring, the prosenchyma disappears from the pith and a number of gum cells appear scattered in the starch filled pith (Figs. 7, 9).

The sepals.

The sepals possess an unbranched vascular bundle which fades a little higher up in the sepal. The bases of the sepals are fused together to form a massive ring (Figs. 9–12). The sepaline ring harbours a large number of conspicuous gum cells in its tissue (Fig. 7). In the mature flower, the gum cells become vacant and thick walled. The outer surface of the sepals is uneven in *C. chinensis*, bearing prominent tubercles (Figs. 10, 12). These develop due to hypertrophy and radial elongation of the cells in the region of the tubercles. The sepaline ring is almost smooth, without any tubercles, in *C. hyalina* (Fig. 11). The sepals begin separating at the level of the apex of the ovary (Fig. 19). Their margins are curved outwards or inwards in *C. chinensis* (Fig. 19). The sepals are about six layered thick in the median region (Fig. 25) and at the tubercles but elsewhere they are three, two, or even one layered at the extreme margin.

The petaline and the staminal supply.

After supplying to the sepals, a large amphicribral bundle is left in the centre and a number of feeble traces, mostly consisting of phloem, are seen at the periphery (Fig. 7). The peripheral traces constitute the vascular supply of the petals and the stamens. The petaline traces arise alternate to the sepaline ones (Figs. 7, 8). The staminal traces arise alternate to the petaline ones but they follow them almost simultaneously (Fig. 7). In *C. hyalina,* however, after the development of the sepaline ring, the vascular tissue of the thalamus forms a plexus (Fig. 8). It soon breaks up into the central amphicribral bundle (Fig. 11) and a number of peripheral traces; the latter constituting the supply of the petals (Fig. 8) and the stamens.

The corolla tube and the stamens.

The corolla tube contains ten vascular bundles (Figs. 9, 10); five for the petals and the other five for the stamens. They are almost equally developed in *C. chinensis* (Figs. 9, 10) but in *C. hyalina,* the staminal bundles are better formed than the petaline ones (Fig. 11). Right from the base, the corolla tube is full of the gum cells (Fig. 27) which occur more profusely in the basal region of the tube (Fig. 26). They occur in the hypodermal, sometimes epidermal, or even in the sub-hypodermal region of the corolla tube. The tube is made up of five to six layers of cells (Figs. 26, 27) but the cells buldge out at the median position of the petals to give them a deltoid appearance. The petaline lobes appear at the level of the apex of the ovary (Fig 19). The corolla tube becomes much thicker near the anther region as the filaments prepare separating from the corolla tube. As the corolla tube breaks up into lobes, the stamens also separate from the corolla tube, their filaments, however, remain attached to an adjacent margin of the corolla lobe for sometime. The gum cells are present in the connective of the anthers (Figs. 24, 31).

The staminal scales.

Histologically the staminal scales are petal-like. The nonvascular scales remain completely fused with the corolla tube at its base. They are borne at the bases of the staminal bundles (Figs. 12, 16). The scales remain fused for sometime with the adjacent scales by their margins. They emerge out from the corolla tube by a tangential split in its tissues over the petaline bundles. The scales remain fused with the corolla tube (Figs. 12, 16) until the tube segments into the petal lobes (Figs. 19, 23). The glandular fingerlike processes borne towards the upper margins of the scales may be seen in a section while the scales as such have almost disappeared (Figs. 19, 23). These processes are made up of one or two densely protoplasmic cells, probably of the nature of gum cells, surrounded by a number of almost similar cells (Fig. 21). The central cells become thick-walled but the peripheral ones remain thin-walled.

The staminal scales are absent in *C. hyalina*, and they do not occur in all the species of *Cuscuta*. They are also not reported to be present in other members of the family Convolvulaceae. Tiagi & Gupta (1963) however, found them in a similar situation in *Evolvulus alsinoides*, belonging to the Convolvulaceae.

The Disc.

Inside the corolla tube, there is an annular disc on the thalamus (Figs. 10, 11). It occurs just below the ovary. Its cells are meristematic, richly protoplasmic, vacuolate, possessing prominent nuclei, but do not have any perceptible starch grains. The disc tissue merges gradually with the more central starch laden tissue of the thalamus. Gum cells are found scattered in the tissue of the disc (Fig. 29).

The gynoecium and its vascular supply.

After the sepals, petals, and the stamens have been duly supplied with vascular bundles, some feeble traces are left at the periphery but inward the disc (Fig. 10). These traverse above the tissue of the disc or may even pass through it to enter in the ovary wall. The central amphicribral (Figs 7, 9) bundle gives rise to two traces in the antero-posterior direction which enter the ovary wall as carpellary dorsals (Fig. 9). They become quite prominent after the emergence of the ovarian chambers (Fig. 13). The central strand now splits up into two bundles which are uninverted and are placed almost at right angles to the carpellary dorsals (Fig. 10) They are the fused ventral bundles belonging to the fused margins of the adjacent carpels; the margins extending almost to the centre of the ovary (Fig. 12). As the locules appear, the ventrals split up into two each in order to supply the ovules (Figs. 12–14).

In the basal region of the ovary, the parietal placentae are massive and the two almost fill up the whole ovarian cavity (Figs. 12, 13). As the ovules appear, borne on their margins, the placentae dwindle in size, providing room to the ovules (Figs. 13, 14). The cells of the placenta are laden with starch, and gum cells occur within the placentae and the carpellary septum (Figs. 12–14). The epidermal cells of the carpellary margins, just a little ahead of the attachment of the ovules, develop a glandular tissue which completes the septum (Fig. 15). The placental epidermis also proliferates to form glandular obturators just at the micropyles of the inverted ovules (Figs. 1–4, 13, 14). Soon after the completion of the septum, the fused margins of the adjacent carpeis separate out, thus forming a slit-like cavity in between the two carpels (Figs. 16, 17). A little higher up, the margins of the same carpel fuse together (Flg. 18) and thus the two carpels become almost separated in the upper region of the ovary (Figs. 18, 30). A transmitting tissue develops where the carpellary margins meet and fuse (Fig. 18).

There are two styles borne separately on the carpels (Figs. 1, 3). The carpellary dorsals descend downwards in the detached portion of the carpellary septum, thereafter ascending upwards into the style (Figs. 19, 23). The stigma is capitate and it contains a number of gum cells in the hypodermal region (Fig. 20). The epidermal cells of the stigma are palisadelike and glandular (Fig. 20). The cells of the style are narrow, elongated and uniformly thickened; however, denser at the angles (Fig. 20, 22).

The Ovary Wall :

The ovary wall is about four layered in thickness (Fig. 28). Gum cells occur in the hypodermal region (Fig. 28). They are particularly abundant in the upper region of the ovary (Fig 19) where the whole of the hypodermis is occupied by these cells. Besides the carpellary dorsals, there are some feeble vascular bundles in the ovary wall. Often a continuous zone, in the middle region of the ovary wall appears like a conducting tissue (Figs. 14, 15, 18). This is especially true for *Cusuta hyalina.*

It is noteworthy that the gum cells have been observed in the upper portion of the ovary wall, as well as in the connective of the anthers in *Evolvulus alsinoides* (Tiagi & Gupta, 1963).

Discussion

Placentation :

In the subgenus Eucuscuta to which *Cuscuta hyalina*, and *C. chinensis* belong, anatomically the placentation is parietal. There is a prominent central amphicribral bundle which breaks up into two uninverted bundles that lie almost at right angles to the radius of the carpellary dorsals. Each in turn splits into two to supply the ovules, attached to the adjacent margins of the carpels. The sterile basal region of the ovary is filled by the two massive parietal placentae which fuse in the centre, thus filling almost completely the whole ovarian chamber. As the placental strand divides into two, and then into the ovular supply, the carpellary margins recede somewhat making the ovary almost unilocular. After the insertion of the ovules, however, the carpellary margins forming the incomplete septum produce glandular tissue which fills the space in between them, completing the septum. From the above, it may be concluded that on anatomical grounds (Puri, 1952) the placentation in these Cuscutas is parietal, and not axile as hitherto believed. In the upper region of the ovary, the carpels separate from each other. This is accomplished by separation of the fused margins of the adjacent carpels and their fusion with the other margin of the same capel.

While in subgenus Eucuscuta, the placentation is distinctly parietal; it is not exactly so in the subgenus Monogynella. In *Cusuta reflexa*, and *C. lupuliformis*, belonging to the latter, the axile placentation appears to be on its way to become parietal (Tiagi, 1966). Instead of a central placental strand, there is a small ring of vascular bundles in *C. reflexa* and *C. lupuliformis*. After giving traces to the septum on either side, this ring breaks up into two arc-shaped structures, lying in an uninverted fashion but on the radius of the carpellary dorsals. They split up into two bundles each which supply to the ovules directly. The arc and the two resulting bundles represent the ventrals belonging to the margins of the same carpel. The resulting ventrals, however, are not fully inverted but they lie more or less on the same radius as the carpellary dorsal. Topographically the ovules appear to be borne at the margins of the adjacent carpels in the imperfectly unilocular ovary on the seemingly parietal placentae.

Eames (1961) believes that parietal placentation has not been derived from the axile but Puri (1952) has emphasised that in almost all cases, the parietal has originated from the axile placentation as a result of the withdrawal of the placentae from their original central position due to the reopening of the carpels, and retraction of their margins.

Summary

The flowers of *Cuscuta hyalina* and *C. chinensis* are pentamerous; tetramerous flowers are quite common in the former species. The vascular bundles in the thalamus are discrete and collateral. The sepals, petals, and the stamens are one traced each Staminal scales are present in *C. chinensis*; absent in *C. hyalina*. The base of the ovary forms a nectariferous disc. A central amphicribral strand constitutes the carpellary supply. Towards the antero-posterior direction, it gives rise to the carpellary dorsals. The strand then divides into two uninverted bundles which in turn split into two each to supply the ovules directly. The placentation is interpreted as parietal. At the base, the ovarian cavity is filled with the placental tissue but as the ovules appear, the carpellary margins recede making the ovary incompletely two celled. The interrupted space in the septum is filled by a glandular growth from the carpellary margins. The placentae form a glandular obturator at the micropyles of the inverted ovules. In the upper region of the ovary, the two carpels separate from each other. They bear their own styles with a capitate stigma. The carpellay dorsal continues upto the stigma.

Acknowledgements

I am grateful to Professor P. Maheshwari, F.R.S. for encouragement, and to Professor M. M. Bhandari for the identification of *Cuscuta chinensis.*

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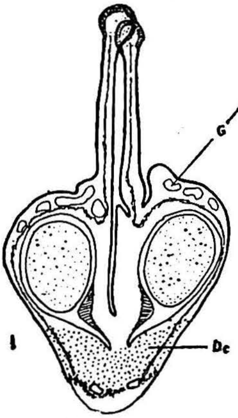
Plate I

Figs. 1–14 (Figs. 3, 4, 8, 11, 14, *Cuscuta hyalina*; rest of *C. chinensis*). Fig. 1–4. L.s. gynoecium, disc, obturator, ovules, gum cells. Fig. 5. T.s. flower bud, thalamus. Fig. 6. Same, sepaline traces, pith prosenchymatous. Fig. 7. Same, gum cells in calyx tube, petaline and staminal supply organising; note carpellary bundle in the centre. Fig. 8. Same, sepaline ring, petaline and staminal supply organising from the vascular plexus, patches of prosenchyma. Fig. 9. Same, calyx and corolla tube, carpellary dorsals, placental strand in the centre. Fig. 10, 11. Same, thickenings in inner epidermis of calyx tube, corolla tube with petaline and staminal bundles, disc, carpellary supply. Fig. 12. Same, staminal scales; the two parietal placentae fused in the centre, ovarian chamber filled with placental tissue, ovular supply. Figs. 13, 14. T.s. ovary, incompletely two chambered, ovules, obturator. (A=staminal bundle; C=petaline bundle; D=carpellary dorsal; Dc=disc; G=gum cell; K=sepaline bundle; Ob=obturator; Ov=ovule; Sc=scale; T=thickenings; V=carpellary ventral).



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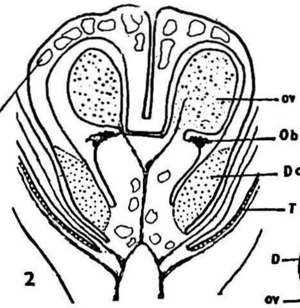

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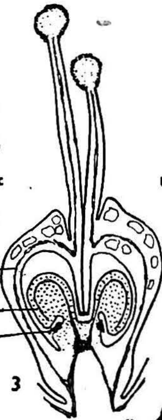

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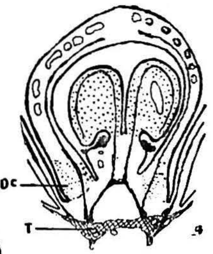

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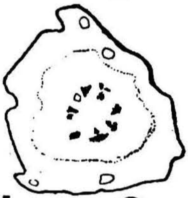

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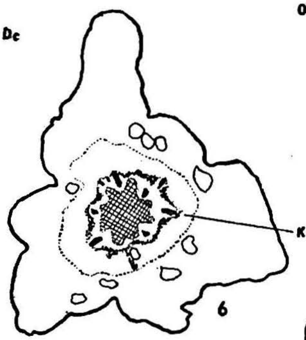

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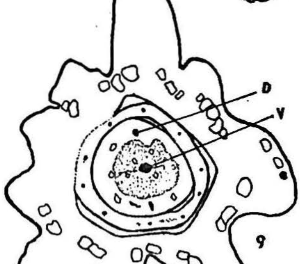

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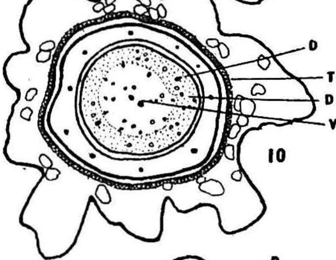

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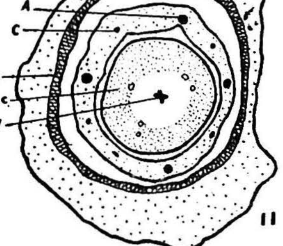

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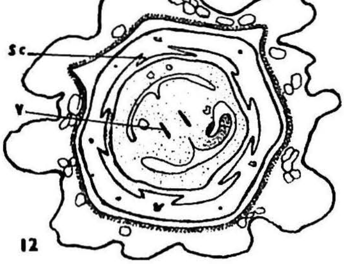

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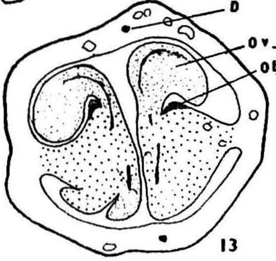

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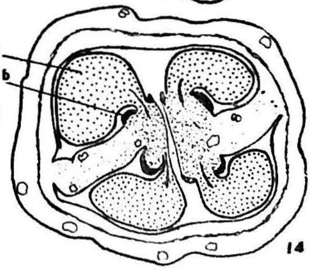

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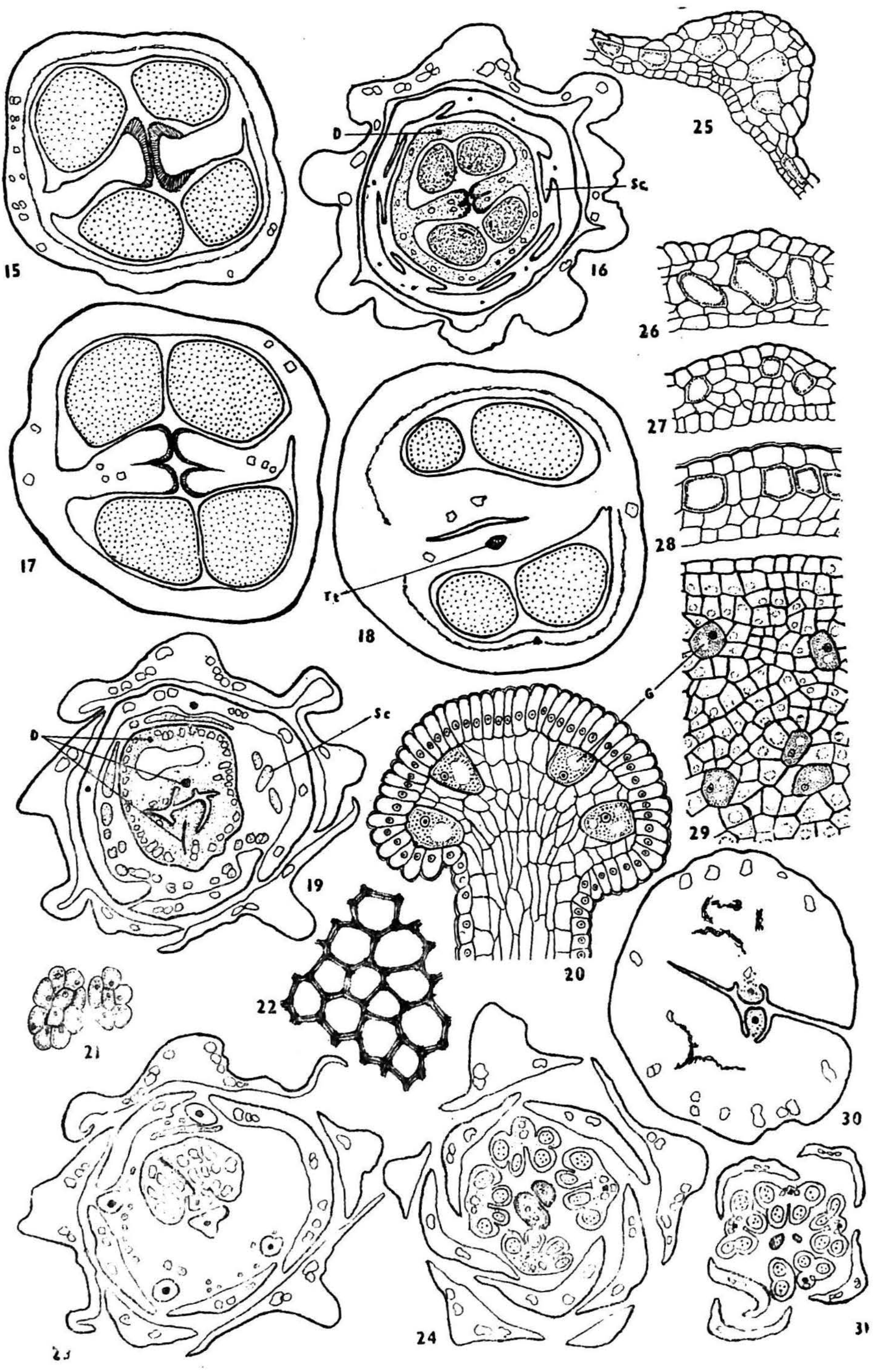
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Plate II

Figs. 15–31 (Figs. 15, 17, 18, 30, 31, *Cuscuta hyalina* ; rest of *C. chinensis*). Fig. 15. T.s. ovary, continuous conducting tissue in the ovary wall, carpellary margins glandular, two chambered ovary. Fig. 16. T.s. bud, calyx, corolla tube with staminal scales, fused margins of adjacent carpels separating. Fig. 17. T.s. ovary, carpellary margins separating. Fig. 18. Same, margins of the same carpel fused together; note the slit in between the two carpels, transmitting tissue. Fig. 19. T.s. bud, apex of ovary, styles differentiating at the slit, gum cells. Fig. 20. L.s. stigma, capitate, gum cells. Fig. 21. T.s. staminal scale processes. Fig. 22. T.s. stylar conducting tissue. Fig. 23. T.s. bud, bases of styles. Fig. 24. T.S. same, five sepals and petals, only four stamens, two stigmas. Fig. 25. T.s. a portion of sepal, gum cells. Figs. 26, 27. T.s. a portion of corolla tube. Fig. 28. T.s. a portion of ovary wall, gum cells. Fig. 29. T.s. a portion of disc, gum cells. Fig. 30. T.s. apex of ovary, bases of styles. Fig. 31. T.s. bud, five petals, four stamens, two stigmas. (D=carpellary dorsal; G=gum cell; Sc=scale; Tt=transmitting tissue).

‘CHARCOAL ROT’ OF SESAMUM IN AJMER (Raj.)

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The present communication reports the occurrence of the ‘Charcoal Rot’ or the ‘Tar spot’ disease on ‘Til’ (*Sesamum indicum* L.) which is grown as an important oil crop all over Rajasthan. It is caused by a species of *Macrophomina* which was reported earlier from other parts of India, but not so far from Rajasthan (Butler and Bisby, 1931).

The symptoms of the disease observed under the field conditions in Ajmer are the wilting of the apical parts of the plants, followed by loss of turgidity by the leaves and within a few days an ultimate drying up of the entire plant without lodging. The drying of the leaves is accompanied by drying and premature opening of the capsules and shrivelling up of the young seeds. This results in a considerable reduction in the yield of the crop. The stem of the diseased plant develops light brown spots at or near the soil surface or even at higher levels; these gradually enlarge, girdle the stem and spread upwards. They turn into lustrous, shining black spots. In slightly later stages, small papillate eruptions appear on the black shining surface of the spots on the stems. At the tips of these papillae, pores develop later which represent the opening of the fruiting bodies of the fungus.

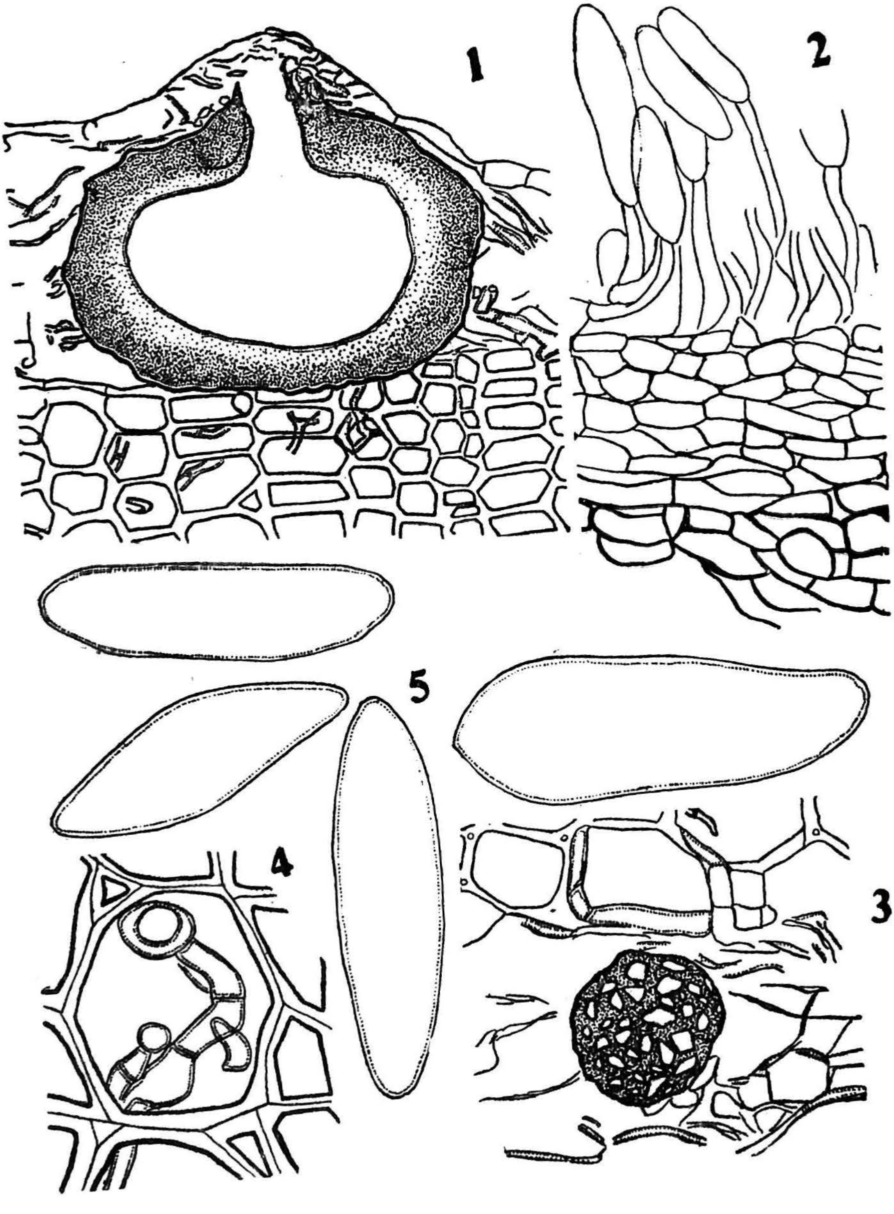
The fruiting structures of the parasite are small, dark, more or less spherical and ostiolate pycnidial bodies (Fig. 1). The pycnidial wall is composed of 6–10 layers of cells (Fig. 2). The cells of the outer two to three layers are dark coloured and thick-walled while those of the inner layers are hyaline and thin-walled. The innermost layer develops fairly long and slender conidiophores (15-25 X 2-4 μ), bearing single, terminal condia. The conidia are hyaline, club-shaped or spindle-shaped to oblong with rounded ends (17.5-27 X 5.5-9.5μ). They are liberated through the ostiole at the tip of the protruding papilla. The host epidermis is completely separated from the underlying host tissues owing to the development of a dense mat of dark coloured, profusely branched and septate hyphae of the fungus. The fungal hyphae are both inter—and intracellular and they appear to penetrate all the inner tissues of the stem. They are clearly seen within the xylem elements (Fig. 4). The conducting elements, however, do not turn black and in this respect the present disease differs from the Fusarial wilts. The fungus also produces numerous and more or less spherical sclerotia scattered irregulaly within the thin-walled tissues of the host. They are composed of dark brown to black coloured, thickwalled, compact hyphae (Fig.3), and range from 65—115 μ in diameter. The fungus thus produces both the sclerotia and the pycnidia within the host tissues.

The parasite was isolated from the host tissues and cultured on Potato-Dextrose agar at room temperature (24°C). The fungus grows very rapidly to produce a flat, dark brown to blackish brown circular colony. It produces abundant small, dark sclerotial bodies all over the colony. No pycnidial fruiling bodies were observed in the cultures even on prolonged incubation. The reverse of the colony is dark black in colour.

Work on the pathogenicity of the fungus is under progress.

The pycnidiospores are hyaline, large and continuous (Fig. 5) They do not become septate during germination. The length to breadth ratio of the spores is about 3:1 i.e. it lies close to the ratio suggested for the species of *Macrophomina* (Ramachandra-Reddy, 1962).

The sclerotial measurements lie within the range of the group C of Haigh (1932) for the genus *Macrophomina*. According to Ramachandra-Reddy (1962) the occurrence of the pycnidial stages of *Macrophomina* on *Sesamum* was recorded earlier by Sawada (1916), Petrak (1923) and Sundararaman (1931). The present paper forms the first record of the occurrence of the pycnidial stages of *Macrophomina* on *Sesamum* from Rajasthan. The spore and other characters of the fungus under study are more like those of *Macrophomina sesami* rather than those of *M. phaseoli* (Maubl.) Ashby. The Charcoal Rot of *Sesamum indicum* may, therefore, be tentatively considered to be caused by *M. sesami.*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The author is grateful to Dr. B.V. Ratnam for valuable guidance; Dr. K.M. Gupta, Head of the Department of Botany, and Shri R.S. Kapoor, Principal, Govt College, Ajmer, for providing research facilities.

Figs. 1–5. *Macrophomina Sesami*

Fig. 1. Section showing pycnidium embedded within host tissue X 450.

Fig. 2. Pycnidial wall, conidiophores and spores. X 1500.

Fig. 3. Sclerotium in host tissue. X 450.

Fig. 4. Hyphae in xylem element. X 1200.

Fig. 5. Spores. X 2500.

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CRYSTALLIFEROUS SCLEREIDS OF TWO SPECIES OF *SCHISANDRA* MICHAUX

By

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Introduction

The literature on the crystalliferous sclereids of *Schisandra* and *Kadsura* is confined to the work of Vesque (1881), Matsuda (1893), Solereder (1908), Bailey and Nast (1948), and Lemesle (1945, 1953, 1955). All these workers considered the crystals to be imbedded in the walls of the sclereids. Since this features is not reported for any other ranalian plant and abundant material of *Schisandra* was available, this study was undertaken to confirm or refute the earlier observations.

Material and Methods

The material of *Schisandra grandiflora* and *S. neglecta* was fixed in formalin-acetic acid-alcohol from plants growing at Rambara (Western Himalayas) and Darjeeling (Eastern Himalayas) during May, 1961, and June, 1962. Sections were cut by rotary and wood microtomes, and stained with safranin-fast green and eosine-crystal violet combinations. Macerations were also made and examined.

Observations

The sclereids occur both in *S. grandiflora* and *S. neglecta.* They are very common in the old roots and stems, but are rare or almost absent in the young roots, nodes, internodes, petioles, lamina, stamens, or carpels. In stems and roots the sclereids usually occur in the inner cortical cells and the secondary phloem. They are distributed singly or in groups of two to five (Figs. 1–10). Not infrequently, they even form linear uniseriate or biseriate tangential sheets within the phloem.

The orientation of the sclereids is parallel or at right angles to the long axis of the organ concerned. The former condition is usually shown by sclereids occurring in the phloem, while the latter situation is exhibited more frequently by those of the cortex. Sometimes, intermediate conditions were also seen in which the sclereids are disposed at various angles to the long axis. In relative abundance, form, size, and manner of branching the sclereids show great variation in both the species. Thus, they may be elongated and fibre-like (Figs. 8, 10), or short (Figs. 6, 7, 9); simply or irregularly armed and branched (Figs. 8-10). These variations are seen not only in sclereids from different parts of a plant, but also among different sclereids from the same region of an organ.

As seen in transection, a mature sclereid possesses non-pitted and asymmetrically thickened walls and a large lumen filled with a finely granular, homogeneous, and resin-like matter (Figs. 1-3). Usually the outer tangential wall is much thicker than the radial and the inner tangential walls. Occasionally, however, greater thickening may also occur on one of the radial walls instead of the outer tangential wall. An outstanding feature of the sclereids is the presence of crystals inside their lumen (Figs. 1-3). These may be rectangular, pentagonal or hexagonal in shape but are invariably found in one or two linear rows next to the much thicker outer wall.

Summary and Conclusions

Matsuda (1893) and Lemesle (1945, 1953, 1955) described that the sclereids possess evenly thickened walls and the crystals are embedded in the wall layers (Fig. 5). Contrarily, Bailey and Nast (1948) emphasized that the walls of the sclereids are asymmetrically thickened and the crystals occur in the thickest inner tangential wall (Fig. 4). The present study has, however, revealed that the crystals are not embedded in the wall layers but are confined along one or two sides in the lumen itself (Figs. 1-3; *see* also Jalan, 1963). The recent findings of Grillos and Smith (1959) for *Pseudotsuga menziesie* in which some of the parenchyma cells in the secondary phloem contain crystals embedded in the resinous material filling the lumen also support this interpretation.

The genus *Schisandra* and its ally *Kadsura* have often been treated as a sub-family or a tribe of the Magnoliaceae (*see* Bentham and Hooker, 1862-1876; Engler and Prantl, 1889-1897; Rendle, 1952). A consideration of the sclereid morphology of these plants, however, does not support this classification. Thus, while all the species of *Schisandra* and *Kadsura* possess non-pitted and crystalliferous sclereids in the phloem, the sclereids in the Magnoliaceae (*sensu stricto*) are pitted and non-crystalliferous. The present study, therefore, provides fresh evidence for excluding the genera *Schisandra* and *Kadsura* from the Magnoliaceae and putting them into a separate family, the Schisandraceae, a conclusion also arrived at on anatomical, cytological, embryological, morpological, and palynological grounds (*see* Jalan, 1962).

Acknowledgements

I extend my gratitudes to Professors P. Maheshwari, F.R.S. and B. M. Johri, F.N.I. for encouragement throughout the course of this investigation. Thanks are also due to Dr. R. N. Kapil for interest, to Dr. B. Tiagi for facilities, and to the Council of Scientific and Industrial Research, New Delhi, for the award of a Senior Research Fellowship during the tenure of which this work was completed.

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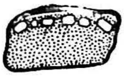
LEGENDS

Figs. 1–10. Crystalliferous sclereids of *Schisandra grandiflora.* Figs. 1–3. Solitary and grouped sclereids from the phloem tissue in transverse section to show the presence of crystals in the lumen. X 640. Fig. 4. Transverse section through a sclereid to show the crystals in the thickened wall. X 560. (After Bailey and Nast, 1948). Fig. 5. Longisection through the sclerenchymatous cells showing crystals in the thickened walls. X 410. (After Lemesle, 1953). Figs. 6–10. Crystalliferous sclereids in the surfacc view to show variation in shape and size. X 321. (*c*, crystal; *l*, lumen ; *w*, wall)



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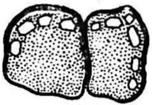

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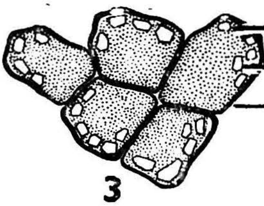

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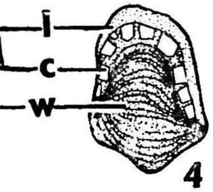

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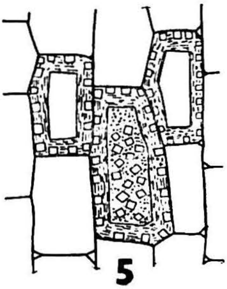

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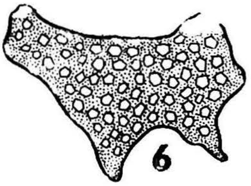

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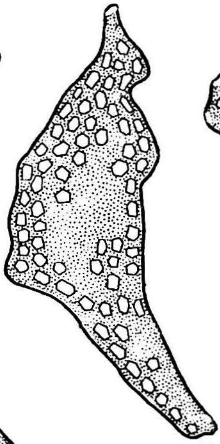

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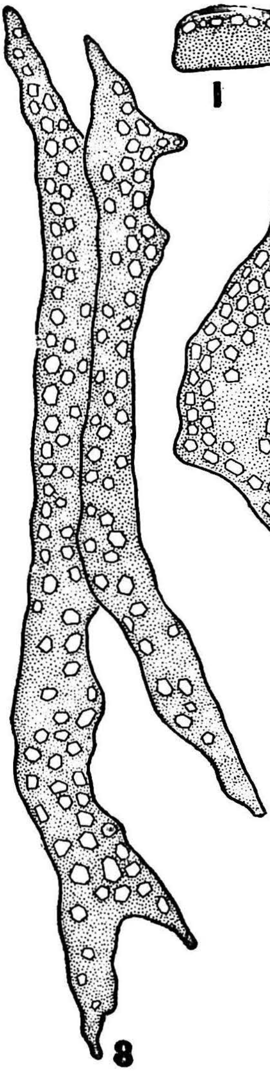

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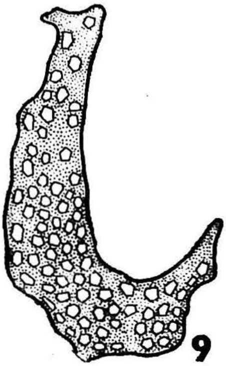

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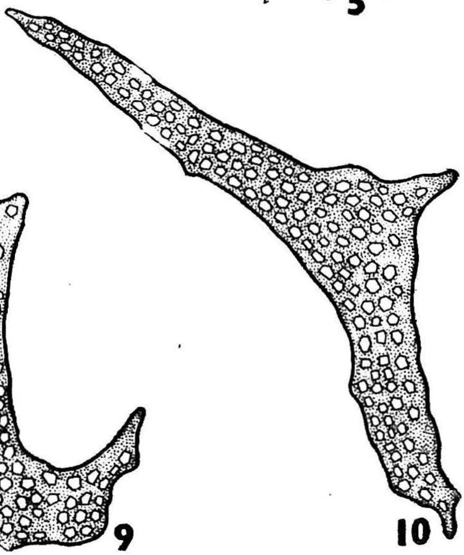

10

SOME FACTS ABOUT THE PHYTOGEOGRAPHY OF RAJASTHAN

By

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Continuous with the famous 'Thar Desert' is the arid zone of Rajasthan. Geographically it is placed on tropics (70 E to 78 E; 22' N to 30' N) as are the other deserts of the world.

The Aravali ranges spread in NE SW direction and divide the region into two plains. The one on the N-W side, consisting of undulating sand dunes, with grading upward slope towards S-W, attains the hieght of 1000 feet above the mean sea level except the fringe near Jaiselmer, and the basin of river Luni which are 400 feet only. It is only in certain depressed areas in this plain where the water accumulates naturally or is collected artificially, that some villages are situated. The soil is not only deficient in organic matter, nitrogen and phosphorus but it also has a poor water retention capacity. Its pH value ranges from 7.5 to 9.5. Strong salinity of the soil is seen at various places like Sambhar, Pachpadra and Balotra where the water is saltish, yielding salt in commercial quantities. The other region on the S-E across the Aravalis is a plain where soil gradually changes from sandy to clayey. Consequently the tract is more fertile having lakes, water reserviors, and seasonal rivulets although they are not perennial.

Considering the rainfall, both these plains can be further divided into two portions each (Fig. 1). However, the rainfall is scanty, as the area falls beyond the full force of the Monsoons that rise from the Arabian Sea or from the Bay of Bengal. Further, whatever clouds may happen to come, float very high above this treeless vast arid region. They are therefore, carried away uninterrupted due to the absence of sufficient humidity which could have started a local precipitation. The rainfall, for these reasons is neither definite, nor regular, having long periods of drought. Further, it is restricted to the monsoon season only, except for a few uncertain and scanty showers during the winter. Moreover, whatever water falls during the rainy season, runs off quickly towards the depressions due to the poor water retaining capacity of the sandy soil, resulting also in soil-erosion. The great diurnal and seasonal variation in the temperature further add to the soil erosion—the worst enemy of man. The mercury touches the extremities, 28° F during the winter and 127° F during summer.

The violent variation in temperature gradually converts the rocks into loose sandy soil which remains uncovered as there is no water and humus to cap it with vegetation initially (Wadia, 1919). The winds blowing in the SW NE direction from February onwards until October considerably add to the miserable plight of the vegetation. The velocity of the wind is 8–10 miles per hour in the earlier period but is accelerated to 20 miles per hour during the month of May. It is obvious that this causes shifting of sand which is already loose, dry and uncovered resulting in the formation of sand dunes. The sand particles are of dimensions which can not float in air but roll on the ground in the direction of the wind. They are halted at any barrier such as a hillock or even a patch of vegetation ultimately resulting in a sand dune which covers any thing that falls under it. Whenever blowing winds are deflected to the WE direction, dust storms are raised which shift the sand dunes small or large, except those which occur in between the hills, or have stationary vegetation cover over them.

Climatic Factors and Vegetation :

Owing to the extremes of temperature, the blowing winds have a dessicating effect on the vegetation. Climatic extremes do have an unfavourable effect on the plant life; it is difficult for any plant to adapt itself to both the extremes equally well.

The irregular and scanty rainfall, with long spells of dry periods in between do not favour the formation of the carpet vegetation. Most of the plants perish due to the paucity of water if there is a long interval between two showers of rain. The absence of carpet vegetation thus exposes the soil to a more intense and deeper solar radiation, resulting in dessication of deeper strata of the soil and the death of the useful micro-organisms. The unceratin and scanty winter rains do not support the growth of trees as well.

If these may come up at all, they remain naked for a major part of the year or their leaves are metamorphosed into spiny structures. Generally the trees are small, e. g. *Anogeissus* spp., *Wrightia* spp., *Butea monosperma* (Lamk.) Taub. and *Tecomella undulata* Seem. Shrubs dominate, as under adverse conditions these adapt themselves better than the trees. (Fig. 2).

The extremes of temperature showing violent variations, also the extreme aridity has resulted into sparse vegetation and animal population. The plants are either (a) ephemerals–mostly herbs, annual and perennial, which grow in moist and shady places and try hurriedly to complete their life cycle within the very short favourable period during the rainy season. These escape drought, such as *Zornia* spp., *Tephrosia strigosa* (Dalz.) Sant. et Maheshw. *Linaria* spp. and many others. Or (b) they endure drought—they are suitably adapted and equipped to combat the xeric environment by developing protective layers, wax in *Calotropis procera* Br., hairs in *Aerva* spp., *Arnebia hispidissima* DC. and many other Boraginaceae; thick cuticle in *Aloe vera* Linn., and multilayered epidermis in plants like *Neriüm* sp.

In plants like *Capparis decidua* (Forsk.) Edgew., *Leptadenia pyrotechnica* (Forsk.) Decne. and *Crotalaria burhia* Ham., leaves are reduced or they are absent during a major part of the year. Their function however, is performed by the stem. Some trees and shrubs remain without leaves for long such as *Anogeissus* spp., *Euphorbia* spp., *Wrightia* spp., *Butea monosperma* (Lamk.) Taub., *Diospyros* spp., *Holoptelia* spp., and *Boswellia serrata* Roxb. etc. In such cases the flowers and leaves stay together for brief periods; leaves usually developing after flowering and fruiting.

Another adaptation to cut down the loss of water is the modification of the leaves, their segments or the entire axillary shoot into spines in plants like *Echinops echinatus* Roxb., *Fagonia cretica* L., *Maytenus senegalensis* (Lam.) Exell. *(Gymnosporia spinosa* Fiori.*)*, *Balanites aegyptiaca* (L.) Del. *Capparis* spp., *Acacia* spp., *Zizyphus* spp. and *Alhagi psuedalhagi* (M. Bieb) Desv. are spiny; stipules are metamorphosed into spines in the last species.

In extreme cases of drought, the plants are reduced to cushion-like habits viz. *Crotalaria burhia* Ham , *Sericostoma pauciflorum*

Stocks., and *Pulicaria* spp. Cushion forming plants like *Pluchea* spp. are said to possess a contractile root system, where in addition to a superficial root system there is another root system extending to a considerable depth in order to tap the sub-soil water of the lower strata.

In general the vegetation of the tract can be classified as scrubby and dwarfed, composed of spiny plants, excepting plants like *Pupalia* spp., *Dyerophyton indicum* (Gibs.) O. Ktze. (*Vogelia indica* Gibs.) etc which usually grow well protected by *Euphorbia caducifolia* and *Euphorbia neriifolia* Linn. over the dry hills.

It is not fair to imagine that the poor vegetation is also poor in number of species, genera and families. On the hilly tracts of the Aravalis, in addition to the slight change in vegetation at different altitudes, the flora however is poor towards the north eastern end, in contrast to that found on the moist southern end. There is also a considerable difference between plants that occur on the western flanks of the hills and those that grow on the eastern slopes (Appendix 1).

The Biotic Factors :

A knowledge of the biotic factors, to some extent, can be of some help in improving the vegetation. The man, who has been excessively lopping the trees, inspite of their being scarce, has done considerable harm but not to the extent, one of his pet animals—the goat, has done. This animal is the most destructive agent since in absence of the carpet vegetation the smaller trees and shrubs are badly damaged, stunted and mutilated by the continous browsing of the leaves and the tender apical portions. What this animal does to trees like *Anogeissus*, can be very well seen, when one happens to see a cushion like form of *Anogeissus* 6″-9″ high on most of the dry hills. Camel is another animal which eats away the leaves and young parts of almost all the trees. Destruction of trees tells upon the growth of other smaller plants which usually grow under them due to the availability of some moisture, shade and richer humus content of the soil.

It is very difficult to check the goats and camels against destruction of the vegetation, as one of the principal occupations of the local persons is to keep pastoral heards. Of the other harmful animals, mention may be made of rabbits, squirrels, and rats which destroy the seeds etc. and the white ants. The damage caused by them is significant.

The biotic factors are thus adverse for the development of a good vegetation. Had not the former rulers of the different states maintained their game reserves, most of the forests present today would not have existed.

The Desert :

The news, that the Indian desert is marching towards the fertile tract of the Indo-gangetic plains, once occupied the head lines and caused much alarm and stir. Much was said and some of the interesting conclusions of all these deliberations state that aridity is due to scanty rainfall, associated with high temperatures resulting in high rate of evaporation, thus lowering the moisture content of the soil to a very poor state. It is also believed however that the climatic conditions, even of the adjoining areas have not deteriorated for the last 40 years (70 years according to Krishnan, 1952). It has also been stated that since 1855 the desert has not been spreading beyond its present boundaries. The question with which one is faced then is about the existence and origin of the desert. There are evidences, which make one believe the presence of *Rhino* in the marshes and forests, said to be covering the area, now an arid zone. The shifting of the Indian rivers towards the west due to the uplift of the Himalayas, and the increase in temperature at the rate of 1°F per century carries some weight if at all there is any correlation between them.

Baluchistan, an adjoining area is reported to have fairly good vegetation, 5000–4000 B.C. (Krishnan, 1952), and it is believed that destruction there was mainly due to the free indulgence of human population. Wadia (1954) opines that Rajasthan too was a fertile tract with rich vegetation some 2500 years ago. The sand is believed to have come from the bottom of an ocean (Oldham 1893), which was supposed to exist here, once upon a time. However, a better explanation is given by Wadia (1919), who traces the derivation of a part of the desert from the weather debris of rocky prominences. The denudated, bare rocks stand testimony to the latter view.

It may therefore be concluded that the biotic factors have accelerated the pace of destruction, which is also favoured by the climatic conditions.

The study of the floristic composition of the vegetation reveals that this tract is a place of confluence of the Asiatic element—Indo-malayan stream, dominating the moist and shady places e. g. *Cleome viscosa* Linn., *Cleome gynandra* L., *Portulaca oleracia* Linn., *Oxalis corniculata* Linn., *Cardiospermum helicacabum* Linn., *Crotalaria retusa* Linn. and species of *Nymphaea* and *Corchorus*, and the N. E. African element. The latter comprises of plants like *Cocculus laeba* DC., *Farsitia jacquemontii* Hk. f. & T., *Capparis decidua* (Forsk.) Edgew. and *Blepharis sindica* Stocks. etc., which are adapted to xeric environment. There are a few endemic plants also, which are commonly occuring in the Indo-gangetic plains.

How this study accounts for the arid conditions ? Had the plants migrated after setting of the xeric conditions and disappearance of the earlier vegetation ? (Fig. 3). On the other hand if these are the pioneer colonisers of the vast arid tract then how to explain the presence of the plants of the Asiatic origin ? (Fig. 4).

One thing is certain that water if available would considerably change the flora of this region.

A devise has been described whereby the dew can be availed as a source of water. The practicability and success of the method under Indian conditions is yet to be seen. Provision of wind breaks may also be very helpful in the development of vegetation in the area.

Acknowledgement

The author is indebted to his teacher, Dr. B. Tiagi, Head of the Department of Botany, University of Rajasthan, Jaipur for guidance and is thankful to Prof. P. S. Sundaram Director, University Maharaja's College, Jaipur for facilities.

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Appendix—**Plants of various habitats.**

On the hills : WESTERN SIDE OF ARAVALIS.

Base : *Adhatoda Vasica* Nees. etc.

Middle : *Securinega leucopyros* (Willd.) Muell., *Rhus mysurensis* Heyne. ex Wt. and Arn., and climbers like *Cocculus* spp.

Top : *Grewia* spp., *Melhania* spp. and trees like *Boswellia serrata* Roxb., and *Capparis spinosa* Linn. and *Maerua arenaria* Hk. f. & T., a climber.

EASTERN SIDE OF ARAVALIS

Abrus precatorius Linn., *Mucuna* spp. and trees like *Diospyros* spp., *Butea monosperma* (Lam.) Taub., *Sterculia* sp., *Crataeva religiosa* Forst. *Cassia* spp., *Salmalia malabarica* (DC) Schott. & Endl., *Cordia* spp. *Terminalia* spp., *Dalbergia* spp., *Shorea* spp. and *Erythrina indica* Lam.

On Sand :

Sand binders—*Leptadenia* spp, *Ipomoea* spp., *Saccharum bengalense* Retz., *S. spontaneum* Linn. and *Citrullus vulgaris* Schrad.

Carpet—grasses and herbs like *Bidens, Aerva* spp. and *Blepharis sindica* Stocks., and in depression plants like *Waltheria indica* Linn.

Trees—*Gymnosporia* spp., *Dichrostachys* sp., *Acacia senegal* Willd. *Prosopis spicigera* Linn., *Capparis decidua* (Forsk.) Edgew., *Balanites aegyptiaca* (L.) Del. (also found at the base of hills) *Tecomella undulata* Seem. and shrubs like *Acacia jacquemontii* Benth.

On Gravel : *Barleria* spp., *Cleome* spp., *Boerhaavia* spp., *Mollugo* spp., *Commelina* spp. and *Tephrosia villosa* Wt. & Arn.

On Rocks : Grasses, and in very moist places species of *Cyanotis.*

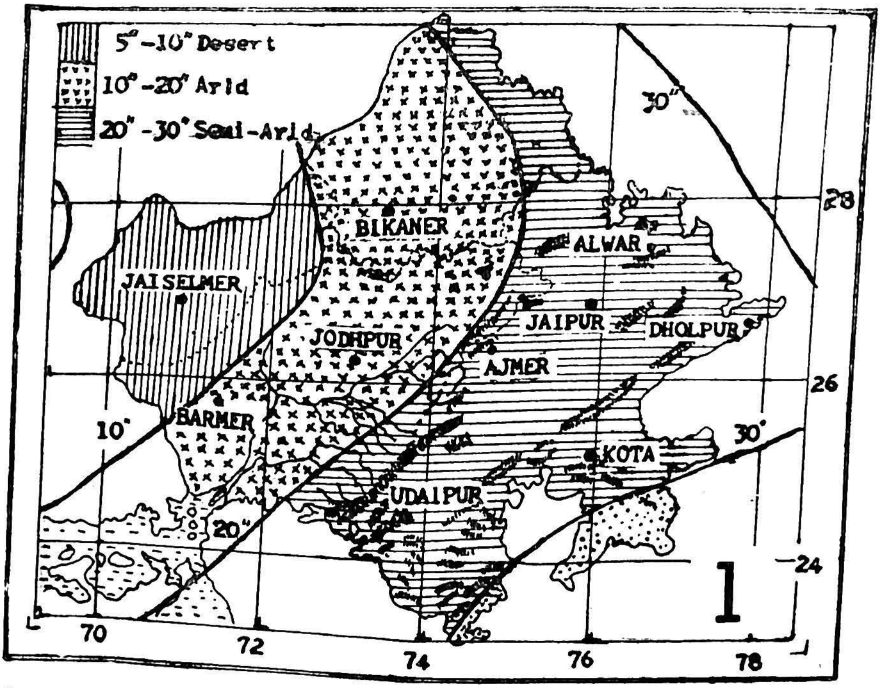
On Clay ; *Indigofera* spp., *Crotalaria* spp. *Enicostemma littorale* Bl. and *Boerhavia* spp.

In Water : (a) Banks—*Caesulia axillaris* Roxb., *Phyla nodiflora* Greene. *Bacopa monnieri* (L.) Pennel. and *Marsilea* spp.

(b) Sandy banks—*Scirpus* spp. and *Equisetum* sp.

(c) Free floating—*Hydrilla verticillata* (L.) Presl., *Ceratophyllum demersum* Linn.

(d) Submerged—*Vallisneria spiralis* Linn. *Potamogeton* spp. and *Ottelia.*


5"-10" Desert
10"-20" Arid
20"-30" Semi-Arid
30"
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DHOLPUR
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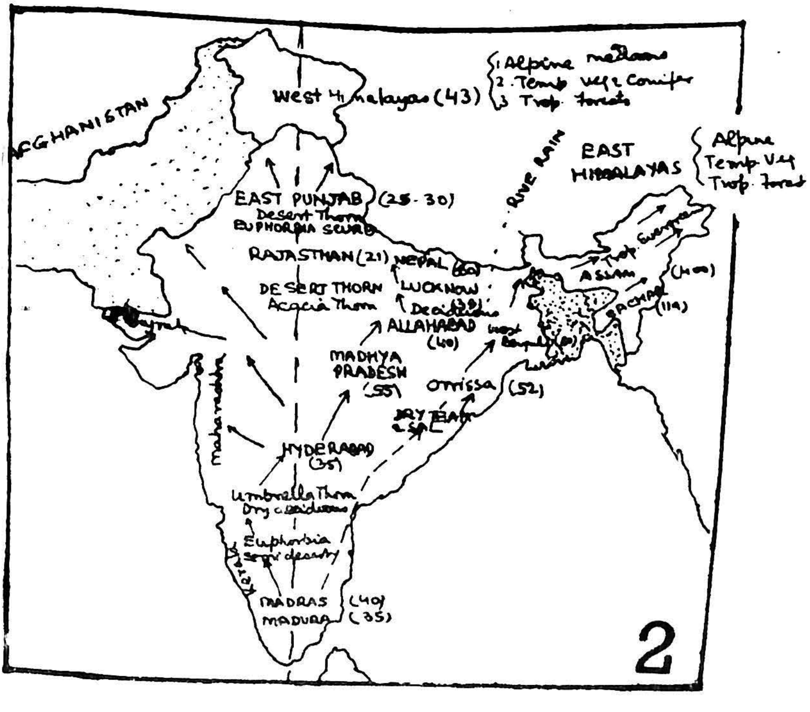
West Himalayas (43)
1 Alpine meadows
2 Temp veg & Conifer
3 Trop. forests
AFGHANISTAN
RIVE RAIN
EAST HIMALAYAS
Alpine
Temp. Veg
Trop. forest
EAST PUNJAB (25-30)
Desert Thorn
EUPHORBIA SCURB
RAJASTHAN (21)
NEPAL (60)
Trop. Evergreen
ASSAM
(400)
DESERT THORN
Acacia Thorn
LUCKNOW (39)
Deciduous
ALLAHABAD (40)
West Bengal (80)
(119)
MADHYA PRADESH (55)
Orrissa (52)
DRY TEAK & SAL
Maharashtra
HYDERABAD (35)
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MADRAS (40)
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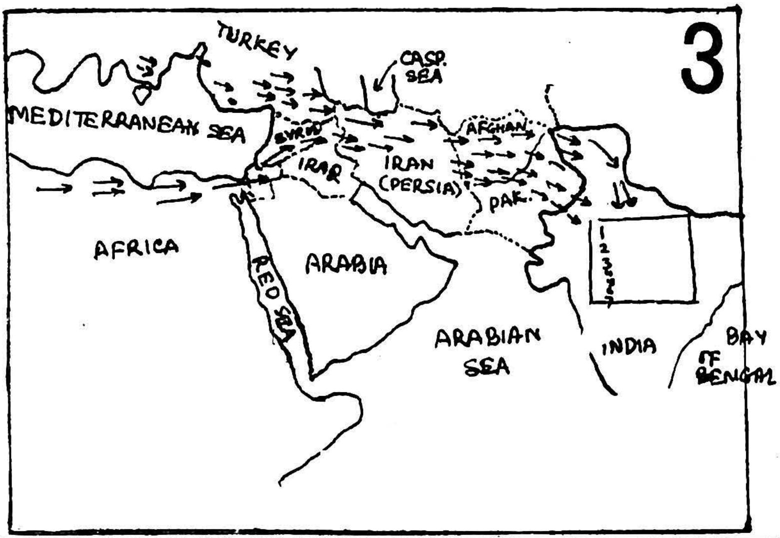
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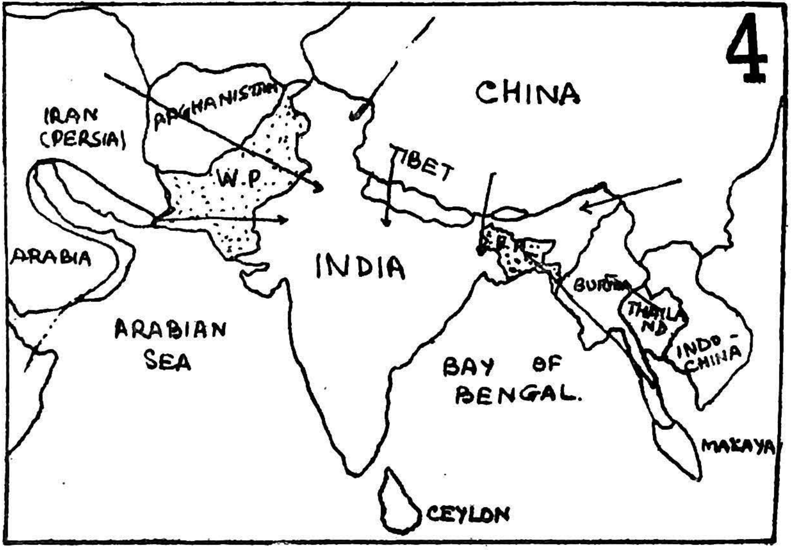
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ARABIAN SEA
BAY OF BENGAL.
MALAYA
CEYLON

LEGENDS

Fig. 1. Map of Rajasthan showing annual rainfall.

Fig. 2. Map of India showing typical growth forms of plants in correlation with the rainfall in different parts. (After Chatterji, D. 1960).

Fig. 3. Map showing the possible route of migration of plants from West Asia and N. E. Africa to the Indian continent. (After Chatterji, D. 1960). Numbers stand for families :

1. *Cruciferae;* 2. *Caryophyllaceae;* 3. *Fumariaceae* (partly); 4. *Caparidaceae* (partly); 5. *Rosaceae* (partly); 6. *Labiatae* (partly) and 7. *Boraginaceae* (partly).

Fig. 4. Map of South East Asia showing the possible lines of migration of plants to Indian continent from neighbouring countries. (After Chatterji, D. 1960).