STUDIES ON THE STRUCTURE AND DEVELOPMENT OF PERICARP AND SEED COAT IN *ROTULA AQUATICA* LOUR.

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ABSTRACT

The structure and development of pericarp and seed coat in *Rotula aquatica* Lour. have been described.

The fruit is an ellipsoidal drupe with four pyrenes. The pericarp is divisible into an inner hard and stony endocarp, a pulpy mesocarp and a thin-walled epicarp. The seeds are curved and the seed coat is poorly developed. All the cells of the integument excepting those of the epidermis break down during development. The epidermal cells develop thickenings on their inner tangential and radial walls at later stages. The endocarp forms a hard shell around the seeds and therefore the seeds are not released from the fruit.

INTRODUCTION

THE family Boraginaceae is divided into four subfamilies, viz., Cordioideae, Ehretioideae, Heliotropioideae and Boraginioideae (Engler and Prantl, 1893). The second subfamily Ehretioideae includes ten genera and about 98 species. In South India, this subfamily is represented by three genera, viz., *Ehretia*, with eight species and *Coldenia* and *Rotula* with one species each (Gamble, 1928). Previous work on the embryology of Boraginaceae has been summarised in an earlier paper (Nagaraj and Fathima, 1967). There have been very few reports on the pericarp and seed coat development in Boraginaceae. It has been reported in *Ehretia laevis* (Johri and Vasil, 1956) of Ehretioideae. and *Cynoglossum amabile* (Millsaps, 1940), *Trichodesma amplexicaule* and

Mertensia sp. (Khanna, 1964) of Boraginioideae. The present investigation includes the structure and development of pericarp and seed coat in *Rotula aquatica* Lour.

MATERIAL AND METHODS

Young and mature fruits were collected from the banks of the rivers Sharavathi and Cauvery, Mysore State, and fixed in Formalin-acetic-alcohol and Carnoy's fixatives. The fruits were treated with 1–2% Potassium hydroxide to soften the tissues. The seeds were treated with 1% Lactic acid at 70–80° C to trace the vascular strand. The material was infiltrated and microtomed. The sections were cut at 5–20 microns thickness and stained with Safranin or Heidenhein's Iron Alum Haematoxylin with Fast green or Orange G in clove oil, as counter stains.

OBSERVATIONS

Fruit.—The ovary is superior, bicarpellary, incompletely four-celled and develops into an ellipsoidal drupe with four crustaceous one-seeded pyrenes.

Seed.—The ovules are anatropous, tenuinucellar, unitegminal and develop into oblong seeds with a thin membranous seed coat. They are scantily endospermic.

Development of pericarp.—The ovary wall consists of undifferentiated, parenchymatous cells before fertilization but later certain changes take place in the different layers and result in a well-demarcated structure which is divisible into an inner hard endocarp, a fleshy mesocarp and a thin epicarp.

At the time of fertilization, the ovary wall is composed of about 14–16 layers of vacuolated, uniformly arranged parenchymatous cells (Plate Figs. 1 and 2). These cells remain undivided; hence there is no increase in the number of cell layers in the pericarp. The vascular strand passes through these cells and it divides the pericarp into two unequal regions, the outer smaller region and the inner larger one. The cells lying internal to the vascular strand, i.e., the inner region, are smaller in size and constitute about seven to ten layers while those lying external to it, i.e., the outer region are larger and constitute about six to eight layers (Plate X, Fig. 2). Tissue differentiation takes place when the endosperm and the embryo reach an advanced stage in development. The cells towards the inner side of the vascular strand get gradually lignified and form the hard, stony endocarp. The lignification

is uniform. The cells lying external to the vascular strand transform themselves into a pulpy mesocarp deposited with starch grains. The epidermis and the hypodermis together form the papery epicarp (Plate X, Figs. 3-8).

Development of the seed coat.—All the four ovules develop into seeds, which are curved. A young ovule consists of a seven- to nine-layered integument when the megagametophyte is eight-nucleate. The innermost of these layers is the endothelium which differentiates at the four-nucleate stage of the megagametophyte. The number of layers remains constant till the later stages of embryo development. The endothelial cells actively absorb the contents of the integument cells and pass them on to the developing embryo so that the cells look practically empty at the tetrad stage of the proembryo (Plate XI, Figs. 9-12). All the cells of the integument excepting those of the epidermis break down at the globular stage of the embryo and are consumed during the development (Plate, XI Figs. 13, 14). The epidermal cells develop thickenings on their inner tangential and radial walls at the globular stage of the embryo (Plate XI, Fig. 14). In a mature seed, the unthickened outer tangential walls of the epidermal cells also break down so that only the thickened portions of the epidermis form a thin papery seed coat (Plate XI, Figs. 15, 16). The seeds are, therefore, never released from the fruit. The endocarp forms a hard shell around them.

DISCUSSION

The structure of pericarp and the seed coat shows variations in Ehretioideae and Boraginioidae. In *Ehretia laevis* (Johri and Vasil, 1956), the pericarp shows a stony, ridged endocarp, a brown pulpy mesocarp and a smooth epicarp. The Boraginioidae are diverse in the structure of pericarp. Among the members investigated so far, in *Cynoglossum amabile* (Millsaps, 1940), the epicarp is highly calcified with glochidiate outgrowths and spinescent papillae, the cells of the mesocarp are thin-walled, while the one-layered endocarp shows lignified ramifications. In *Trichodesma amplexicaule* (Khanna, 1964) the epicarp shows hard, cutinised cells, the mesocarp thin-walled cells and the one-layered endocarp is highly cutinised. *Mertensia* (Khanna, 1964) exhibits echinulate epicarp, thin-walled cells in the mesocarp and cutinised cells in the endocarp. However, the mesocarp is similar in all these members since it shows uniformly thin-walled cells, while the cells of endocarp show similarity in *Ehretia laevis* (Johri and Vasil, 1956), and *Cynoglossum amabile* (Millsaps, 1940), in being lignified. *Rotula aquatica* resembles *Ehretia laevis* (Johri and Vasil, 1956) in the structure and develop-

FIGS. 1-8. Development of pericarp in *Rotula aquatica* Lour.

FIGS. 9-16. Development of seed coat in *Rotula aquatica* Lour.

ment of the pericarp. However, there are certain differences. While the endocarp is ridged in *Ehretia laevis* (Johri and Vasil, 1956) it is uniform in *Rotula aquatica*. The number of cells in the pericarp increases enormously in *E. laevis* (Johri and Vasil, 1956) subsequent to fertilization, while they remain constant resulting in a thin pericarp in the present species. The epicarp is unarmed in Ehretioideae while it is either armed with spines or hair in Boraginioideae.

The seed coat is less conspicuous and poorly developed in all the members worked out so far. In *Ehretia laevis* (Johri and Vasil, 1956), the cells of the integument collapse and are consumed during development. Only the epidermis of the integument with its thickened portions persists in the seed coat. In *Cynoglossum amabile* (Millsaps, 1940) and *Trichodesma amplexicaule* (Khanna, 1964), the seed coat consists of five to seven layers of thin-walled cells while the remaining cells of the massive integument break down and are consumed during development. In the present investigation, *Rotula aquatica* shows similarities with *Ehretia laevis* (Johri and Vasil, 1956).

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EXPLANATION OF FIGURES

PLATE X

FIGS. 1-8 Fig. 1. L.S. ovary after fertilization, $\times 150$. Fig. 2. Portion marked 'X' in Fig. 1. enlarged, $\times 1455$. Fig. 3. L.S. fruit with cellular endosperm (relatively early stage) $\times 105$. Fig. 4. Portion marked 'X' in Fig. 3. enlarged, $\times 873$. Fig. 5. L.S. fruit with cellular endosperm (relatively advanced stage), $\times 75$. Fig. 6. Portion marked 'X' in Fig. 5, enlarged, $\times 727.5$. Fig. 7. L.S. mature fruit, $\times 40$. Fig. 8. Portion marked 'X' in Fig. 7, enlarged, $\times 450$.

(EMB, embryo; END, endosperm; ENDC, endocarp; EPIC, epicarp; MESC, mesocarp; OV, ovule; S, seed; VS, vascular strand; ZY, zygote.)

PLATE XI

FIGS. 9-16. Fig. 9. L.S. ovule with fertilized megagametophyte, $\times 451.5$. Fig. 10. Portion marked 'X' in Fig. 9, enlarged, $\times 1,455$. Fig. 11. L.S. seed with cellular endosperm (relatively early stage), $\times 150$. Fig. 12. Portion marked 'X' in Fig. 11, enlarged, $\times 100$. Fig. 13. L.S. seed with cellular endosperm (relatively advanced stage), $\times 100$. Fig. 14. Portion marked 'X' in Fig. 13, enlarged, $\times 1,000$. Fig. 15. L.S. mature seed, $\times 100$. Fig. 16. Portion marked 'X' in Fig. 15, enlarged, $\times 1,000$.

(DEG ITC, degenerating integument cells; EMB, embryo; END, endosperm; EPI, epidermis; IT, integument; ITT, integumentary tapetum; T, thickenings; ZY, zygote.)