On the Development of the Fruit and Behaviour of Flower Organs in Purple Passion Fruit (*Passiflora edulis* Sims)

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Introduction

In Japan, the cultivation of the passion fruit on a commercial scale was commenced several years after the second World War. At present, some hundred hectares of land have been planted for the trees in the southern regions of both Kagoshima and Miyazaki prefectures. The mature fruits are saled for juice-making at the local factories. As passion fruit juice gains popularity more and more among Japanese for their excellent flavour with subacid taste, the production of the fruit will increase every year in future. Hence, various experimental studies on its cultivation and the solution of factorial problems are seriouly wanted, but so far few reports are to be seen. The research reported here was undertaken to study the morphology and development of the fruit and the flower organs in passion fruit for the pupose of getting basical knowledge which must promote future investigations. In this research, what most interested the author was the development of the aril in which the yellow juice is contained and the blooming-stage behavior of both stamens and styles, which may be concerned with pollination.

Materials and Methods

One year seedlings from the seed has been transplanted in the distance of 2×2 m. in the field of branch station of the college farm (City of Ibusuki, Kagoshima prefecture) on April, 1961. These trees were trayed on the bamboo racks with one meter height, flowers and fruits born on them were used as research materials in the second and fourth years after planting. After anthesis the measuring of the outer size of the fruit was carried out with the ten fruits on the trees at five days interval successively, at the same time, other ten fruits were plucked in order to measure the weight of fruits, seeds and juice-sac as well as to investigate the internal structure. Anatomical studies were made with materials stocked in 70 % alcohol.

Results and Discussion

1. The movement of pistil and stamen.

Diagrams of the flower is shown in Fig 1.[1] In the bud stage, the filaments stand erect and the anthers face to the ovary, but at the beginning of the opening of flower the former bend outwards, while the latter turn downward, becoming rectangular to the filaments. Moreover the styles standing straight at the initial opening stage take curving

movements outwards; while they are left to be horizontal during the flowering period, the stigmas facing over the anthers at the same time. (fig. 2. B.) It is supposed that such turning of the position of both style and filaments, reducing the distance between the stigma and anthers, may be necessary for securing the success in the pollination which is to be carried out by means of either wind or insects. In general, it is recognized that in fruit-setting the flowers born on the rather upper portions of the vine are inferior to that born on the base portions; the styles of the former being likely to remain erect after flowering, as shown in figure 2. A.

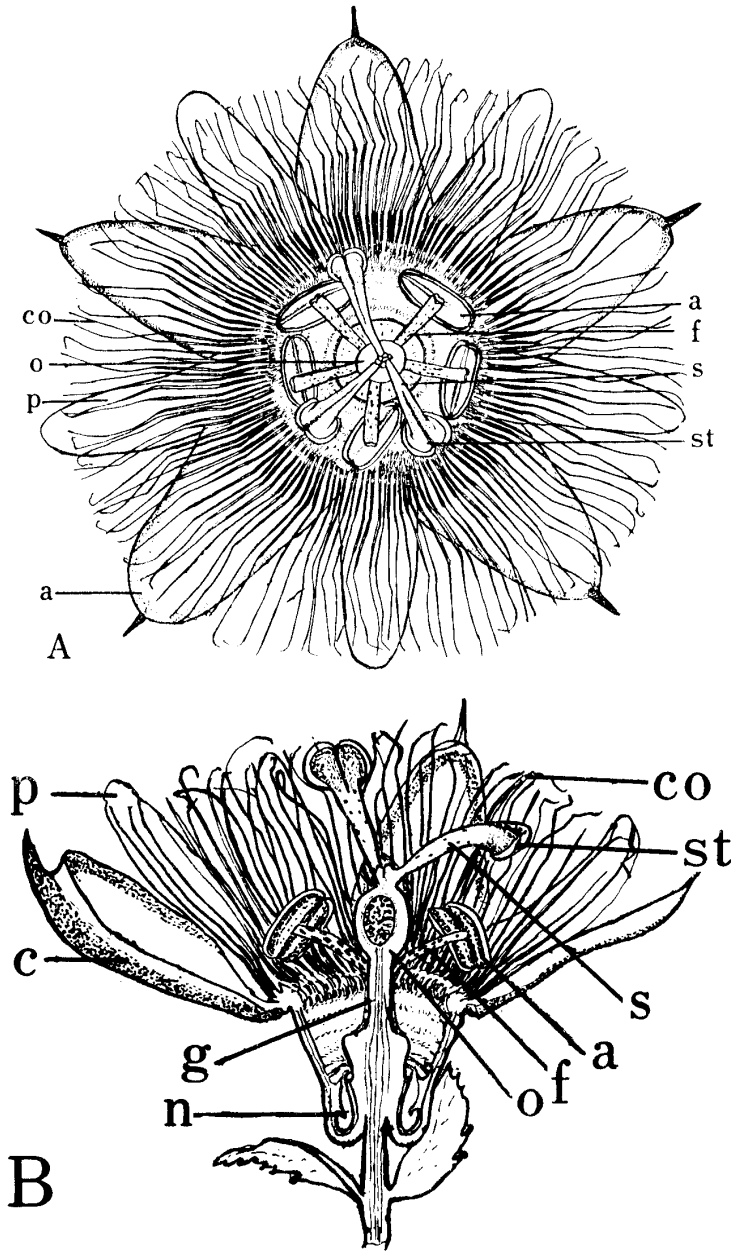

Fig. 1. Diagrams of the flower. A. face view (1/1). B, longitudinal section. (1/1). c, calyx. p, petal. co, corona. a, anther. f, filament. st, stigma. o, ovary. g, gymnophore. n, nectary.

Fig. 2. Photograph of two kinds of flowers. A ; The styles remain erect during the period of flowering. B : The styles bend downward and the stigmas face over the stamens.

2. Morphology and development of the fruit.

The fruit, developing from ovary, is groburous or egg-shaped, deep purple when ripe. Anatomical morphology of the young fruit-coat and ripened one are presented in figure 3. Endocarp consists of thin layer and can be lipped off easily when ripe, and the cells under the epidermis contain purple colour pigments at the ripening stage. Mesocarp is 0.3 0.5 cm. in thickness, being composed of 3 4 layers of thick-walled collenchymatous cells and many layers of thick-walled prarenchymatous cells, while as the fruit ripens decomposition and crushing in the latter layers occurs. The thickness of the mesocarp in the ripened fruit gets thinner than that in the young fruit.

Decreasing curve of thickness of mesocarp is shown in figure 4. It is seen that juice-sac, as is to be mentioned later in detail, increases its volume while the mesocarp continues to decrease its thickness. (cf. Fig. 4. 5.) This Phenomenon and the evidence got of the fact that the vascular bundle running through the mesocarp is penetrated into the juice-sac, indicate that some amount of storage substances in the crushed cells of the mesocarp may be transported into the juice-sacs to promote their growth.

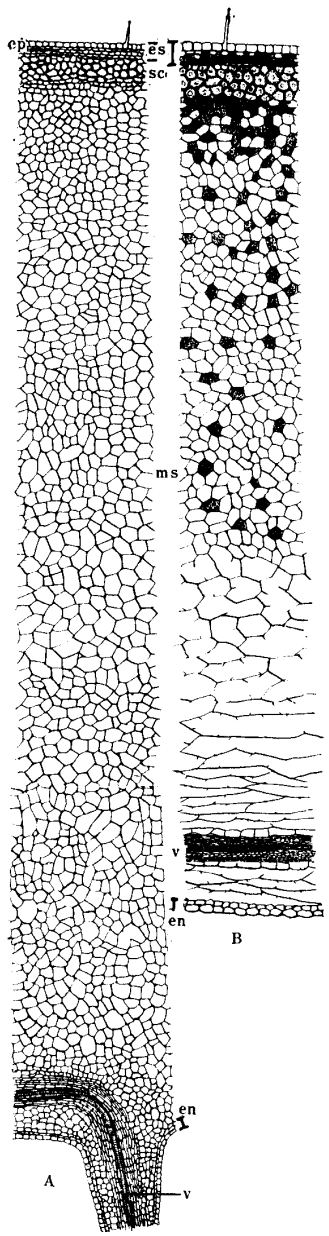

Fig. 3. Longitudinal sections of fruit coat of immature (A) and ripened fruit (B). ep, epidedermis. ex, exocarp. en, endcarp. ms, mesocarp sc, sclerenchyma. v, vascular bundle. (×20)

In the immature fruit a lot of chloroplasts are enclosed in the cells of mesocarp parenchyma, especially in the outer portions, while at the ripening stage all the chroloplasts disappear and purple colour pigments appear in many cells. The endocarp is composed of very thin cell layers. The aril arises from the endocarp with

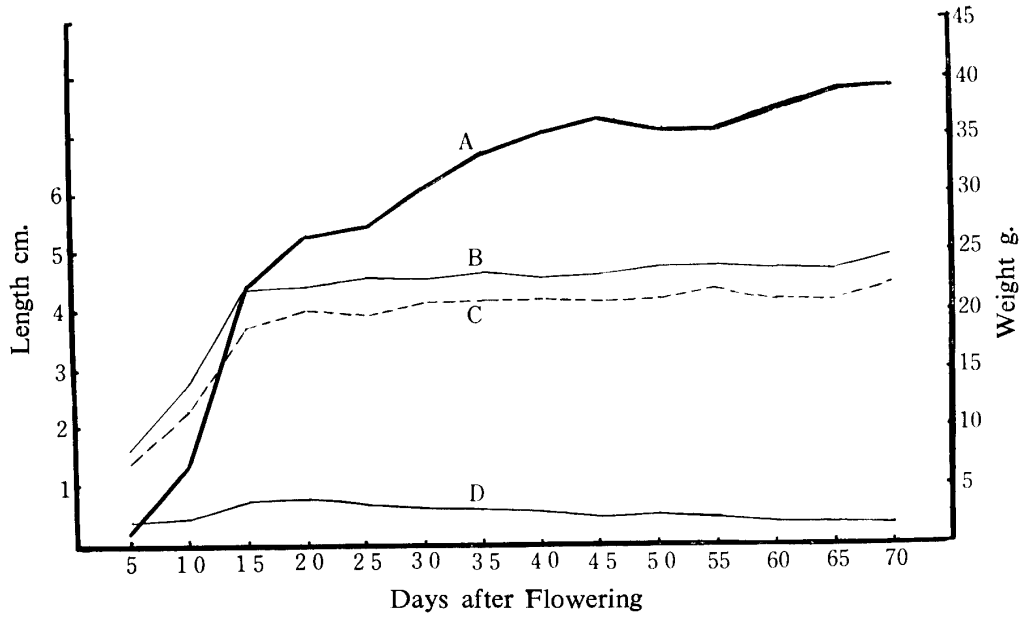

Fig. 4. Curves show growth of fruit with time. A, weight. B, longitudinal diameter. C, cross diameter of whole fruit. D, thickness of fruit coat.

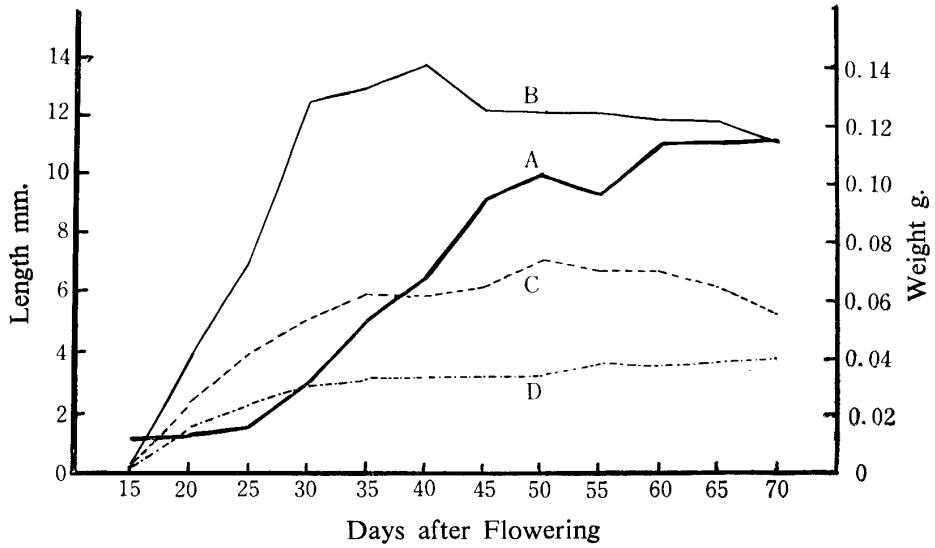

Fig. 5. Curves show growth of juice sac with time. A, weight. B, length. c, cross diameter. D, narrow cross diameter.

some cells of the mesocarp.

The origin of the aril enclosing one seed, is ascertained to be the endocarp and small portions of mesocarp.[2] Many arils are oriented in three or four rows longitudinally at the three positions of the endcarp wall as shown in figure 6. As the fruit ripens, the aril develops into the sac which contain yellow juice and gerations pulp, the development of which will be illustrated later in detail. Developments of the fruit are shown graphically in figure 4. Both the longitudinal and transversal axis develop very fast during 15 20 days after anthesis, then developing rates becomes very slow and reaches maximum length

of 4.7 and 4.3 cm. respectively. The weight of the fruit increase rapidly from the tenth day after anthesis and attains half the weight of ripened fruit on the fifteenth day, when ripened it reaches 38.5 g.

3. Development of juice-sac.

The developing phases of the juice-sac are graphically and diagramatically illustrated in figure 5, 6, and 7. At the flowering time, the aril is thin and menbranous around the seed, but begins its expanding growth at the base 10 days after flowering, and this growth occurs both downward and upward. This expanding growth forms a bag which is termed juice-sac. The sac takes maximum length after 40 days and width 50 days after flowering, while maximum weight at maturity, 1.4 cm., 0.6 cm. and 0.1 g. respectively.

As the juice sac increases its size and volume, the fore top becomes roundish and its membrane becomes so slender that it may be teared easily by the light impact. Juice pulp and yellow pigments appear in the juice-sac for the first time about 25 days after flowering, and their concentration is high in the lower portions. At the time of maturity, concentration of sugars in the sac shows approximately Brix 15, measured with the hand

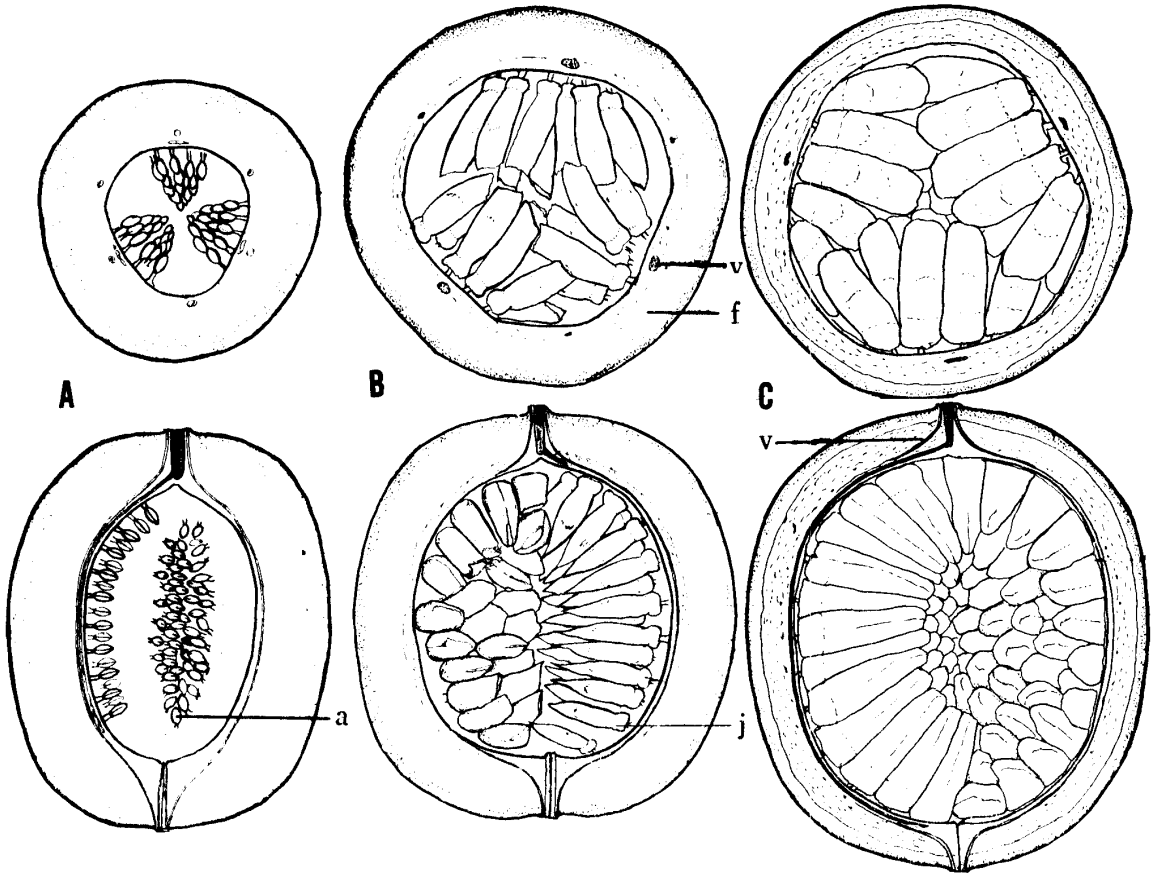

Fig. 6. Diagrams of fruit, illustrating development of juice sac. upper, cross section. lower, longitudinal section. A, 15 days after flowering. at this stage, aril is seen only and juice sac does not developed. B, 45 days after flowering. juice sac has acute apex. C, 75 days after flowering. juice sac fully developed with rounded apex. a, aril. j, juce sac. v, vascular bundle. f, fruit coat. (1/1)

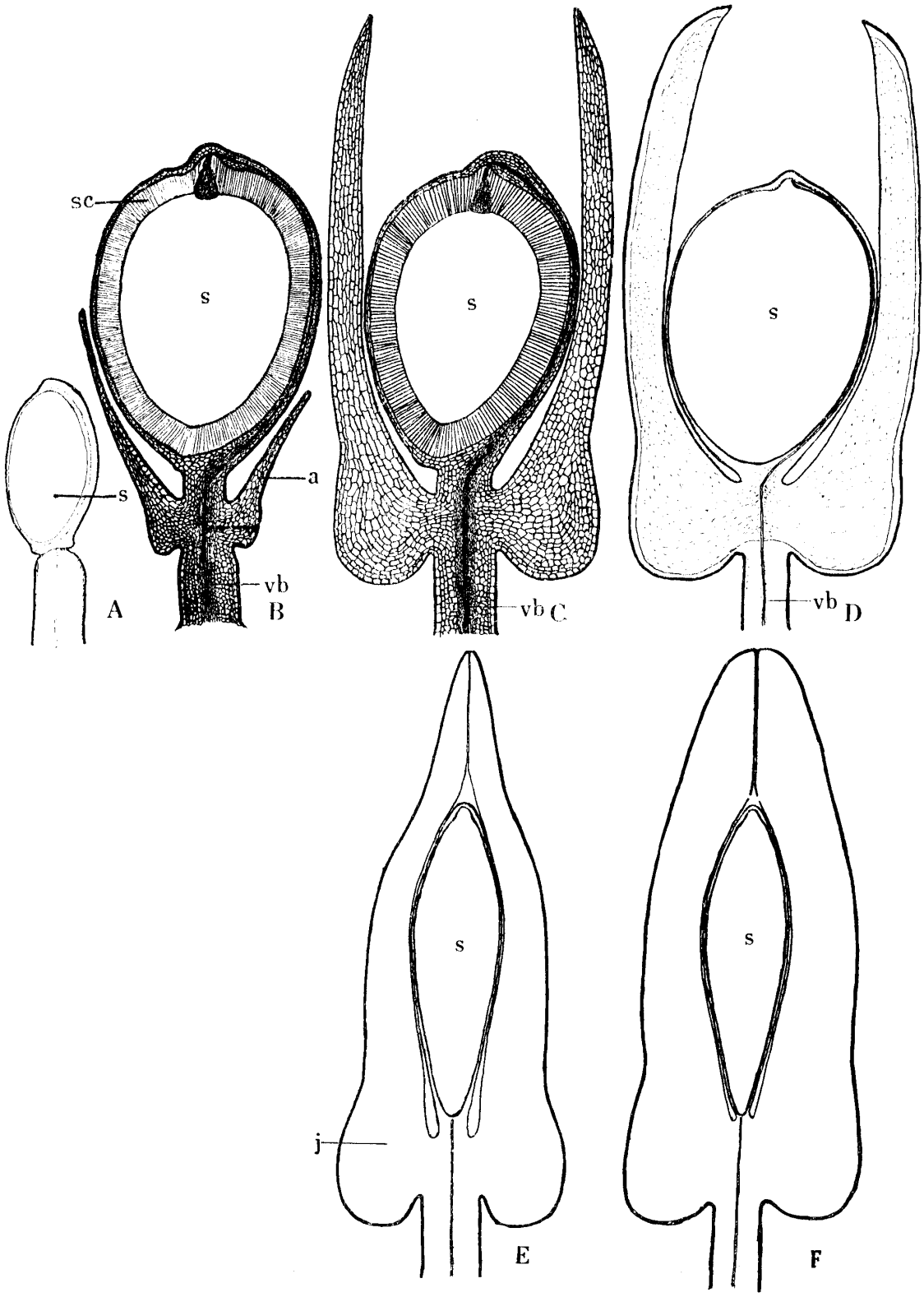

Fig. 7. Cross section of the juice sac. A, 15 days after flowering. B, 25 days. C, E, 45 days. D, F, 75 days. s, seed vb, vascular bundle. a, aril. j, juice sac. sc, seed coat (×6)

refractometer.

4. Morphology and development of the seed

As given in figure 8. vascular bundle passes through the one side of the aril and reaches to the top of the seed, then penetrates into the seed and branches into some lobes.

The mature seed is black in colour, flattened ovoid in shape and have irregular roughness with very hard coat. Seed-coat is thin and transparent 5 days after anthesis, milky whitish 40 days after and black 70 days after. The embryo has two great roundish cotyledons. The developmental phase is shown in fugure 6. and the trend of the developmental curve is seen to be rather gentle.

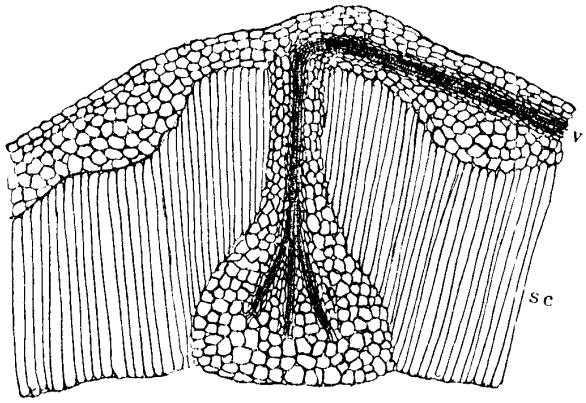

Fig. 8. Cross section of the seed coat apex. v, vascular bundle, s. c. seed coat. (×70)

Summary

Morphological and anatomical studies on the fruit and the behaviour of flower organs of the passion fruit are described in this report.

Curvature movements of the pistil and stamen are observed to have a relation with the success in pollination.

The development of the juice-sac, which is the most important organ seen from the view of utility of the fruit, is illustrated in detail with a graph and diagrams.

Acknowledgement

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References

1) Ochse, T. T. etc. Tropical Agriculture vol. 1 1961 p.p. 709~711

2) Webber, H. J. The Citrus Industry vol. 1. 1948 p.p. 688~689