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SENSITIVITY TO LIGHT IN PLANTAGE SEEDS AS RELATED TO SEED COAT STRUCTURE

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Abstract

The seeds of three different species of *Plantage*, namely *P. crassifolia, P. major* and *P. squarrosa*, were studied with regard to their varying sensitivities to light.

It was found that the seeds of *P. major* were the smallest in size among the three species studied and exhibited the highest degree of sensitivity to light during germination, being light-favoured. *Plantage crassifolia* and *P. squarrosa* had larger seeds and showed lesser sensitivities to light during germination.

The cause of such differences was sought in the seed coat structures of the different species. The seeds of Plantage major contained a well-defined, pigment-full cellular palisade layer, which is not present in the other two species.

Phylogenetic relations among the three species under investigation were discussed in the light of their behaviour during germination.

Introduction

In a previous investigation (TADROS and REZK, 1966), it was shown that the seeds of some species of Plantago exhibit varying degrees of sensitivity to light during germination. Thus, in complete darkness, the seeds of the species studied showed low germination percentages, that differed from one species to another. The results of the above-mentioned investigation showed that the seeds of *Plantago major* gave 2% germination in the dark, and 66% in bright daylight: those of *P. crassifolia* gave 12% and 38% respectively, in the two treatments; while those of *P. squarrosa* gave 50% and 92%.

Further work (REZK 1967a, 1967b; REZK et HORVÁTH, 1968) was carried out with the seeds of *P. major*, in which the phenomenon was studied from the points of view of the effects of different chemical and physical factors on the breaking of the dark-induced dormancy. It was concluded that the behaviour of *P. major* seeds differed considerably from that of *Lactuca sativa* v. Grand Rapids, experimented on in similar investigations by many other authors (e.g. BORTHWICK et al., 1954).

For *Plantago major* seeds it was observed in common practice in our laboratory that scratching them with sand paper resulted in a rapid onset and a high percentage of germination in the absence of the brinht daylight usually needed. This has drawn attention towards a possible role of the seed coat in previnting the seeds from germination in the dark. Seed coat dormancy in general is a wellknown phenomenon previously investigated by CROCKER et BARTON (1953) and others.

The aim of the present investigation is to answer the questions: a) Is there any probable correlation between the varied sensitivities to light in the seeds of the species of *Plantago* studied and their morphological structures. b) Can this variation in sensitivity to light be correlated the their previously suggested interspecific phylogenetic relationships (TADROS et REZK, 1970).

Materials and Methods

Seeds of *Plantage crassifolia* FORSK., *P. major* L. and *P. squarrosa* MURR. v. *brachystachys* BOISS. were collected from naturally-occurring plants in the vicinity of Alexandria. Microtome sections (20 μ thick) were prepared, which were stained with crystal violet (saffranin. Free-hand sections mounted in water were also prepared for comparison, as the colouring material was not leached out in the latter.

Observations

The seeds of the three species showed considerable morphological variation.

Plantago crassifolia and *P. squarrosa* seeds are lightbrown in colour with a smooth testa, while those of *P. major* darker sculptured testa. Further, the general shape of the seed differs from one species to another. *P. squarrosa* seed is nearly ellipsoidal in outline and concave-convex in T. S. measuring about 1.5—2 mm long. *P. Crassifolia* seed is narrower and more or less plano-convex in T. S. reaching 1.0—1.5 mm in length. *Plantago major* seed is triquetrous to irregular in outline, and nearly triangular in T. S.; it measures about 1 mm long.

Examination of the median transverse sections of the seeds of the three species of *Plantago* reveals basic differences both in shape and in the structure of the testa. They all agree in possessing a thin, delicate, mucilageproducing epidermal layer. This layer has previously been studied in considerable detail for two species of *Plantago*. DODDS (1953) described it in *P. coronopus* seed from the point of view of its ecological value to the plant as a cementing material, that fixed the seed in the soil and allows the growing radicle to penetrate it easily. With regard to the development HYDE (1970) examined and described a similar layer in the related species *Plantago ovata*.

Below the epidermis in *Plantago squarrosa* and in *Plantago crassifolia* there is a layer of undifferentiated compact cells that contain a brown colouring material, responsible for the seed colour. This is the pigment layer. In the former species this layer becomes thinner on the hylar side of the seed.

In *Plantago major* on the other hand, below the transparent epidermis lies a definite layer of cells whose radial and inner tangential walls are densely thickened and pigmented. This is the palisade or the malpighian layer. It is to this layer that the dark colour of the testa and its sculptured appearance are due. This colouring material seems to be lost during dehydration and staining techniques, so that the thickened walls are colourless in the permanent microtome sections. In the free-hand section mounted in water, it retains the colour and shows a definite dark-coloured cellular layer. The thickening is shown to be deposited in the from of radial striations. This palisade layer tightly ensheathes the contents of the seed below the epidermis.

Similar testa structures in the seeds of some crucifers have been reported by EDWARDS (1968), and VAUGHAN (1956 and 1970). This is especially met with in *Brassica* spp. and *Sinapis* spp., which are reported to exhibit some type of dormancy.

Discussion and Conclusions

It is clear from the above study that there are basic differences in the structures of the three species of *Plantago* studied, parallel to their degrees of sensitivity to light. As the pigmentcarrying layer increases in thickness, the need for a greater amount of light to induce germination also increases, or in other words, the germination percentages in the dark decrease. This attains a maximum in the seed of *Plantago major,* where this layer is quite definite and obvious. Thus, it can safely be supposed that a direct relationship may exist between the thickness of this pigmentcarring layer and the germination light requirements of the seeds.

The interference of the seed coat with the germination has been interpreted as taking place through any of the following routes:

a) Mechanical, preventing the enlargement of the embryo.

b) Hindering light from entering the embryo.

c) Preventing some sort of inhibitor that may be present inside the seed from being leached out (ROBERTS, 1969).

d) Limiting certain oxidation processes from being completed. IKUMA and THIMANN (1963) have attributed the promoting effect of red light on the germination of lettuce seeds to the influence of this factor on the production of a set of enzymes that enable the radicle to elongate outwards through the seed tissue.

GUGLIADA et al., (1967) working with the photoblastic seeds of *Datura ferox,* stated that the oxidised products with whose production the seed coat interferes would permit the photomechanism to become operative or, once this has been completed, to overcome the blockage imposed by the "inhibitor".

EDWARDS (1968) investigated the dormancy of charlock *(Sinapis arvensis L.)* seeds, which are shown to have a testa structure similar to that of *Plantago major* seeds, and attributed this phenomenon to the phenol and mucilage content of testa hindering the diffusion of oxygen into the tissue of the embryo.

That the seed coat may completely block the germinationpromoting effect of red light was demonstrated by SANCHEZ et al., 1967.

Then, it can be stated that in the light-sensitive seeds of *Plantago* and similar species, the seed coats may interfere either directly, preventing light from entering the embryo, or indirectly, preventing some light-sensitive oxidationinhibiting products from being leached out, therebly retarding germination in the dark.

WAREING (1966) reports that it is difficult to see what adaptive value arises from light-sensitivity in seeds and that the more frequent light requirements mean that germination can only occur on the soil surface. He adds that although it is difficult to see any very marked adaptive in light-sensitivity, its ecological importance is unquestionable, especially in the germination of weed seeds following agricultural disturbance of the soil.

TADROS and REZK (1970) have put forward a working hypothesis as regards the interspecific phylogenetic relations in four species of *Plantago*. From that hypothesis it was proposed that *Plantago major* by virtue of its mesophytic character moist habitats and subcosmopolitan distribution, may be regarded as the ancient as compared with the other non-mesophytic species of *Plantago*. e.g. *P. squarrosa* (annual psammophite) and *P. crassifolia* (perennial halophite).

If we non try to correlate the evolutionary tendencies of the species in the light of the working hypothesis mentioned above, it can be said that there is a parallel decrease in the sensitivity to light of the seed with the progress of evolution.

The seeds of *P. major* the more ancient mesophytic species, proved to be acutely light-sensitive, containing a light-impervious layer, the palisade or malphighian layer, that is assumed to be the site of preventing light from entering the seed. As evolution proceeds and new species develop from the more ancient, a decrease in the light-sensitivity is manifested. This may be supposed to have proceeded through the following parallel lines:

a) Change of seed shape from the small closed triquetrous *(P. major)* to the larger, more open plano-convex *(P. crassifolia)* to the concave-convex boat shaped *(P. squarrosa)* seed.
b) Decrease of pigmentation of the seed coat and the disappearance of the palisade light-impervious layer, paralleled by the decreased sensitivity to light.

These conclusions, however, need further verification and evidence through other cytotaxonomic, morphologic and genetic studies.

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