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Morphology of Slender Spikerush Seed (*Eleocharis acicularis* (L.) R.&S.

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ABSTRACT

Slender spikerush is a dense sod-forming aquatic plant that can displace selected undesirable waterweeds. Seed (achenes) can be sown to establish the plant in ponded water. The morphology of seed from cultured and naturally growing plants was studied at light and scanning-electron microscope levels. Seed usually formed naturally in April and May. We found the pericarp to have a thick mesocarp that contained large amounts of a wax-like substance. The seed coat was composed of three convoluted integuments, the innermost cutin-like. When seed germinated, the cotyledonary sheath emerged first, and then the first culm. This was followed by development of the plumule and radicle, and subsequently, numerous culms and roots which eventually led to the formation of an ortet.

Key words: pericarp, wax-like substance, integuments, tubercle, endosperm, germination.

INTRODUCTION

The genus *Eleocharis,* family Cyperaceae, has over a hundred species of aquatic and semi-aquatic plants inhabiting salt marshes, bogs, and shallow water ponds from the tropics to the polar regions of both hemispheres (6). Members of the genus are characteristically without leaves and, therefore, without complex foliar variations. The chief taxonomic differences among the species lie in the structures and organization of the achenes.

Splender spikerush is of interest to aquatic weed specialists because it is capable of displacing the rank growth of several submersed rooted aquatic weeds (10).

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The plants reproduce both sexually and asexually. They can fragment into individual plants usually the result of wave-action or feeding waterfowl (3), and then form new plants elsewhere. Seed is the primary structure that slender spikerush plants utilize to perpetuate the species through long periods of adverse conditions, particularly drought. Freshly harvested seed are dormant.

Information regarding the morphology of achenes of slender spikerush is lacking, though studies have been published on the seed morphology of dwarf spikerush (*Eleocharis coloradoensis* (Britt.) Gilly), a closely related species using scanning electron microscopy and the light microscope (9). The objective of the current work was to provide information that may be useful in identification, seed production, and understanding the gemination of slender spikerush.

MATERIALS AND METHODS

In May 1981, achenes of slender spikerush were harvested from a spikerush nursery at Fresno, California. One thousand seeds were planted outdoors in full sunlight in each of four trays containing water-saturated silty-clay soil kept wet throughout the growing period. Placing the trays in full sunlight avoided any adverse effects on flowering due to shading (1). Observations were made on these inflorescences from these plants and on those growing on a natural site adjacent to a Sierra Mountain reservoir at an elevation of 2,560 m. Seed from both growths were harvested in September 1981.

Fifty specimens of inflorescences and achenes were examined individually with a light microscope. Twenty of each were preserved in a mixture of formaldehyde, ethyl alcohol, and glacial acetic acid (FAA) and embedded in paraplast[2] (4). Eight of the preserved specimens were

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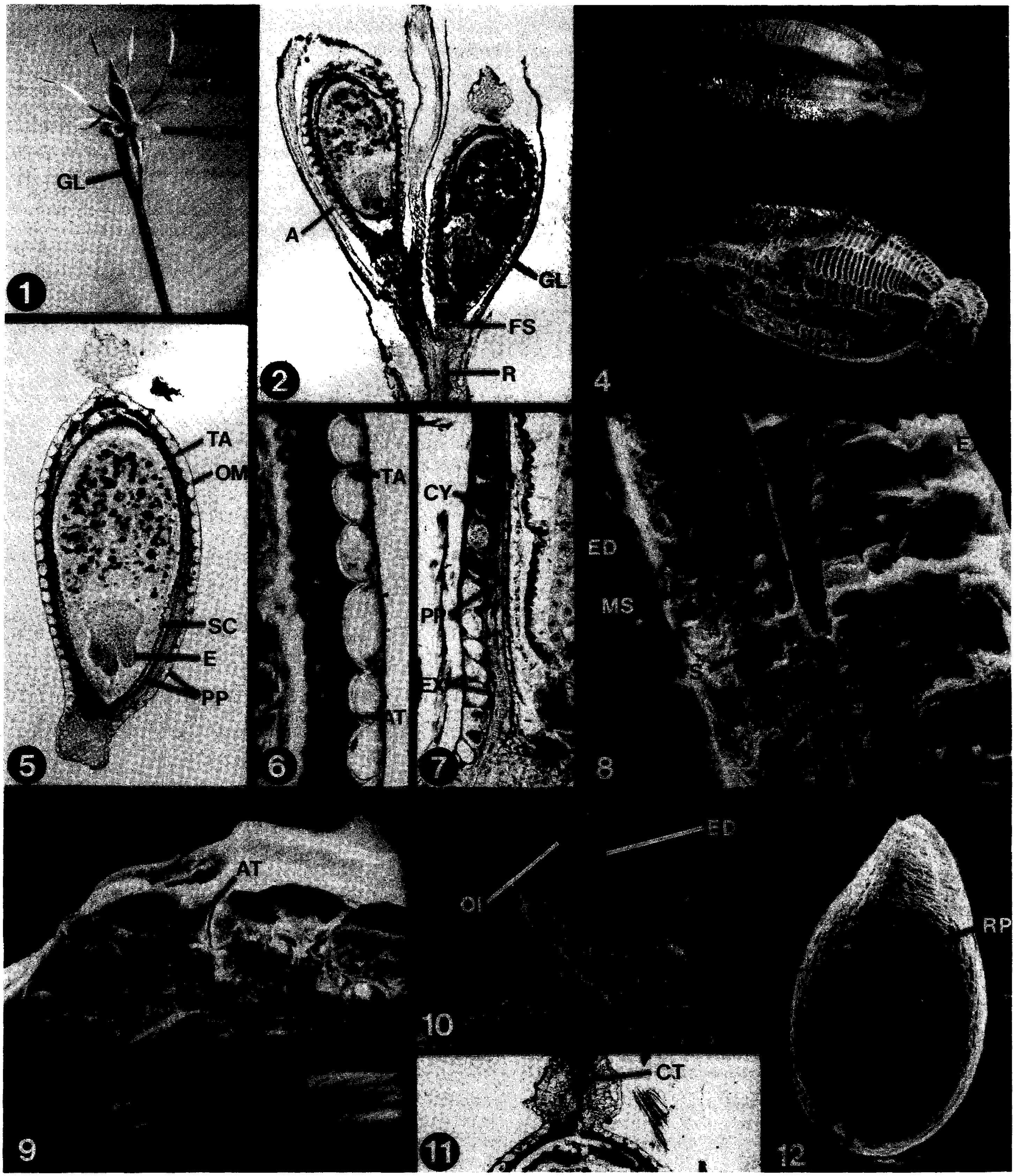
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selected, sectioned (8μM), mounted on glass slides and stained with safranin-fast green.

Tissues examined with a scanning electron microscope were fixed in glutaraldehyde, dehydrated in ethanol, and critical-point dried in carbon dioxide. After coating them with a 50 nm layer of gold palladium in a sputter-coater, the tissues were photographed at 20 kV on a Cambridge model 54 SEM[2].

RESULTS AND DISCUSSION

No morphological variations were noted in seed and flowers grown at the two different locations. Spikes were formed at the apices of culms and bore 3 to 15 flowers (Figure 1). Only 1 to 6 achenes formed on each inflorescence. Emersed plants growing in wet soil usually flowered in April and May; however, the plants were induced to flower within 2 to 4 weeks when desired by lowering the water to the soil surface on submersed plants. Flowering was indeterminate.

This information is important in seed production, and inducing the plants to flower by periodically lowering and raising the water levels allowed one to three seed harvests to be made during one season. Because flowering was indeterminate, seed were collected when an average of 3 large fully developed seed per inflorescence were present. Several natural events were observed to affect seed production. The seed were sometimes knocked off by strong winds, or the flowers destroyed by heavy rainfall. Also, if the summer temperatures were in the 100°F range for several days during flowering, the flowers stopped developing and became desiccated.

The light brown achenes were positioned alternately around the rachis (Figure 2) and each was enclosed by a pair of reddish-green scales. We found the achenes to be obovate (Figure 3) to slightly terete in cross-section. The achenes varied from 0.8 to 1.2 mm long and from 0.4 to 0.6 mm wide. Svenson (6) described the length of achenes as being shorter; however, we included the button-like tubercle on the apex in our measurements. Bristles were lacking on our specimens. Svenson also found that in the northern and eastern United States there were usually 3 or 4 bristles on the achene, but they did not occur on California specimens.

The mature achenes became detached from the rachis at the base of the funiculus. Shattering did not occur and the achenes remained on the plants for several weeks after they were fully developed.

The fresh achene was enclosed in the thin outer tissue of the exocarp (Figure 4). Upon drying, the exocarps withered and were easily ruptured. The surface of the achene (with the tissue removed) revealed a pattern that was typical to only slender spikerush. It was characterized by elongated concave hexagonal depressions formed between longitudinal and transverse (trabeculae) ridges. Mason (1) and Munz (2) reported 40 trabeculae on each seed. We found 40 to 50 on our specimens.

Light micrographs of the cut surfaces of the pericarp and histological preparations of the longitudinal axis of the achene showed that an outer thin layer of exocarp covered the sharply ridged inner area that formed the trabeculae (Figures 5 and 6). The trabeculae appeared translucent and cutin-like. Early in the development of the fruit, these cavities were filled with cytoplasm, but they became vacuolated as the fruit matured (Figure 7).

SEM micrographs showed the mesocarp to have parallel rows of vessels with annular rings along the long axis (Figures 8 and 9). A dense material of waxlike consistency filled the area between the vessels. The endocarp was a thin layer of slightly convoluted tissue (Figure 10). The thickness of the pericarp was approximately 0.04 t0 0.06 mm midway through the longitudinal axis. The exocarp was about 0.02 mm thick and the mesocarp varied from 0.02 to 0.04 mm. Other external characteristics of the fruit included a large depressed tubercle formed by a persistent style at the apex. It had a broad base and usually tapered sharply at the tip (Figure 11). Longitudinal sections through the center of the tubercle revealed the conducting tissues that passed through the style.

The seed was yellow and had a smooth surface (Figure 12). The seed coat consisted of 3 integuments, similar to the seed coat of dwarf spikerush (9) (Figures 13, 14, 15). Longitudinal sections through the seed coat showed that the outer integument was a thin translucent layer of tissue with small protruberances due to the reticulate pattern on its surface (Figure 10). The middle and inner layers were thicker by contrast. The middle integument stained dark. It adhered closely to the convoluted translucent cutin-like inner layer. Other features included a reddish brown chalaza that appeared swollen on some specimens (Figure 16). The straw-colored raphe protruded along one side of the seed. It was 15 to 18 cells in cross section (Figure 17).

Longitudinal and transverse sections through the seed showed a layer of perisperm under the seed coat. It enclosed the embryo and endosperm (Figures 18, 19, 20).

FIGURE ABBREVIATIONS

Key for figures: A, achene; AT, vessels with annular rings; CT; conducting tissue; CY, cytoplasm; CS, cotyledonary sheath; CZ, chalaza; E, embryo; ED, endocarp; EN, endosperm; EX, exocarp; FL, first leaf; FS, funiculus; GL, glume; II, inner integument; M, micropyle; MI, middle integument; MS, mesocarp; OI, outer integument; OM, outer tissue of exocarp; PL, plumule; PM, perisperm; PP, pericarp; R, rachis; RA, radicle; RP, raphe; S, stamen; SA, stigma; SC, seed coat; T, tubercle; TA, trabeculae; WS, waxlike substance.

Plate 1. Figure 1. Influorescence (spike) of slender spikerush, X 6. Figure 2. Longitudinal section of inflorescence showing two achenes attached to rachis, X 68. Figure 3. Freshly harvested intact seed, X 80. Figure 4. SEM micrograph revealing ruptured outer membrane of achene and expose trabecula, X 110. Figure 5. Longitudinal section through mature seed showing pericarp and location of embryo, X 127. Figure 6. Enlarged longitudinal view of pericarp emphasizing the trabeculae and outer membrane of exocarp, X 450. Figure 7. Longitudinal section through immature achene with cytoplasm in cells of the exocarp, X 250. Figure 8. SEM micrograph through the longitudinal section of the pericarp revealing the endocarp, mesocarp, and exocarp. X 1000. Figure 9. SEM micrograph through transverse section of pericarp showing the thick-walled vessels with annular rings, X 550. Figure 10. SEM micrograph showing the thin sheet-like endocarp, X 110. Figure 11. Longitudinal section through tubercle showing conducting tissues, once a part of the flower's pistil, X 100. Figure 12. SEM micrograph of seed with pericarp removed and outer integument of seed coat exposed, X 75.

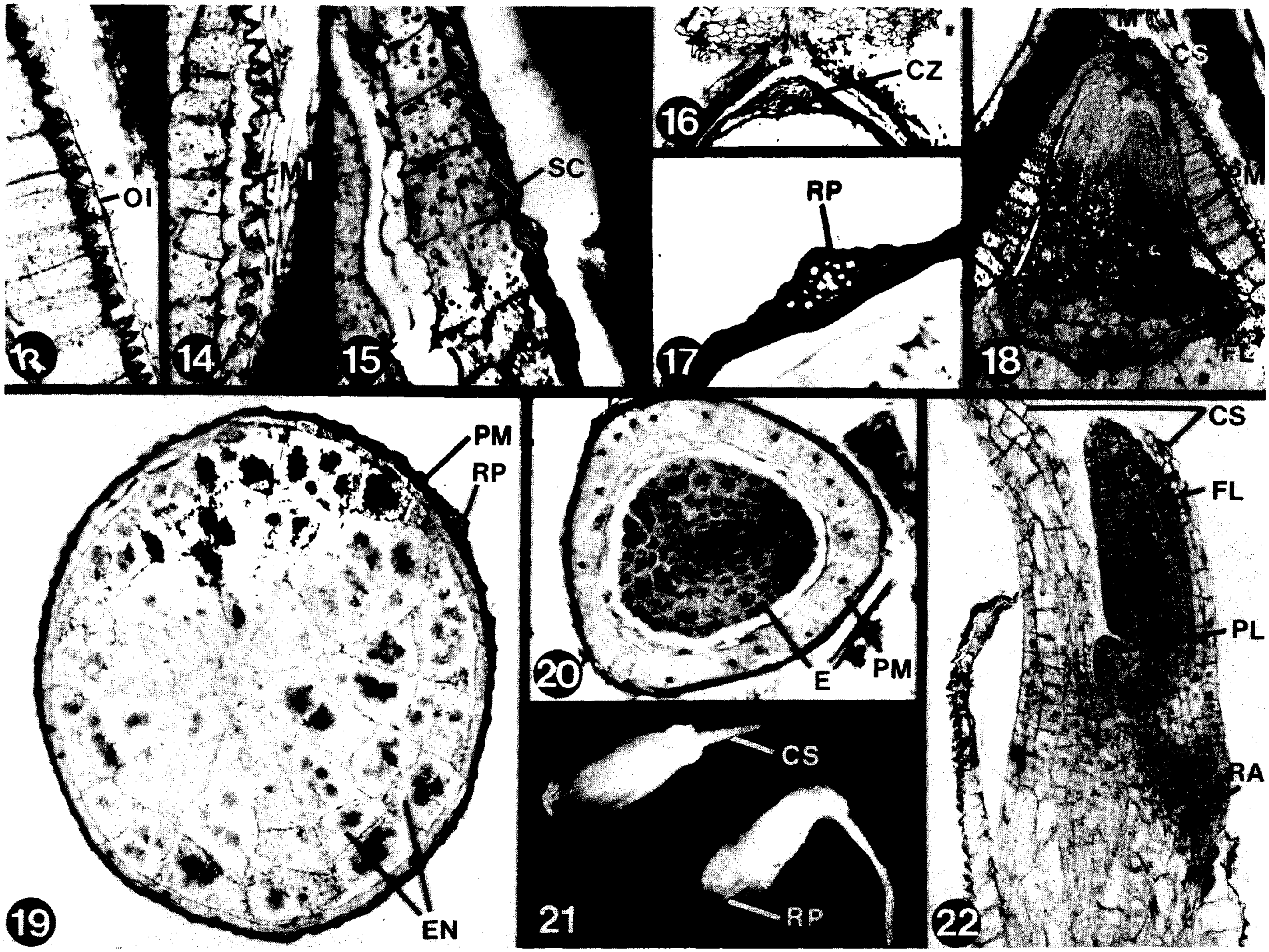

Plate II. Figure 13. Longitudinal section through seed coat showing thin membrane-like outer integument, X 450. Figure 14. Longitudinal section of seed coat with separated cutin like inner and ribbon-like middle integuments, X 450. Figure 15. Intact seed coat showing convolutions of inner- and middle-integuments that stretch during germination, X 450. Figure 16. Transverse section through chalaza, X 150. Figure 17. Cross-section of raphe showing conducting tissue, X 625. Figure 18. Mature embryo with different wall thicknesses of the cotyledonary sheath. Also, the perisperm surrounding and protecting the embryo, X 200. Figure 19. Transverse section of seed showing the cellular struture of the endosperm, X 200. Figure 20. Transverse section of seed through the embryo, X 200. Figure 21. Germinated seed, pericarp removed, with emergent cotyledonary sheaths, X 25. Figure 22. Longitudinal section of germinated seed through the embryo. X 250. Cotyledonary sheath has ruptured along the thin side and the first culm is beginning to emerge.

The perisperm cells surrounding most of the seed were rectangular, except next to the embryo where they were nearly square. The endosperm was light yellow. Formation of the endosperm was nuclear with cellular tissues forming later in its development. These cells were aligned radially in rows from the center of the seed. Light brown globules of an oil-like substance were observed in the endosperm.

The embryogeny of slender spikerush seed was similar to that found in dwarf spikerush (9) and creeping spikerush (*E. palustris* (L.) R. & S.) (15). The embryo sac was of the *Polygonum* type. When the embryo was mature, the cotyledonary sheath which was unequal in thickness, surrounded the swollen first culm (Figure 18). The presence of other structures was evident when the seed were ready to germinate (Figures 21 and 22). The plumule at the base of the first leaf enlarged. Likewise, the radicle, outside of and below the cotyledonary sheath enlarged. When the seed germinated, the cotyledonary sheath emerged first. During the elongation of the growing embryo, the convoluted seed coat stretched, until ruptured by the cotyledonary sheath. This was followed by emergence of the first culm. The primary root formed within one or two days. Formation of these structures was followed by additional culms and adventitious roots, with the eventual development of a complete plant or ortet. An account of the sympodial interpetation of seedling formation has been given by Walters (8). The development of spreading rhizomes, and subsequent numerous ramets (rosettes) at their nodes, eventually produced extensive mat-like growths.

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