*TF-397*, Chalcolithic Culture, 3350 ± 100*
*(3450 ± 100)*

Charcoal from KTH-1, Layer 33, Depth 8 m., Field No. 7. NaOH pretreatment was also given.

*TF-399*, Chalcolithic Culture, 3525 ± 100*
*(3625 ± 100)*

Charcoal from KTH-1, Layer 37, Depth 9·1 m., Field No. 8. NaOH pretreatment was also given.

*TF-400*, Chalcolithic Culture, 3800 ± 105*
*(3915 ± 110)*

Charcoal from KTH-1, Layer 38, Depth 9·60 m., Field No. 9. NaOH pretreatment was also given.

*TF-401*, Chalcolithic Culture, 3190 ± 105*
*(3285 ± 105)*

Charcoal from KTH-1, Layer 39, Depth 10 m., Field No. 10. NaOH pretreatment was also given. Comment: Date is younger than expected.

*TF-402*, Chalcolithic Culture, 3240 ± 100*
*(3330 ± 100)*

Charred wheat from KTH-1, Layer 35, Depth not given, Field No. 11. NaOH pretreatment was also given. Comment: Date is younger than expected.

*TF-405*, Chalcolithic Culture, 3320 ± 100*
*(3415 ± 100)*

Charcoal from KTH-2, Layer 10, Depth 3·5 m., Field No. 14. NaOH pretreatment was also given.

*TF-680*, Chalcolithic Culture, 3850 ± 95*
*(3965 ± 100)*

Charcoal from Trench KTH-3, Layer 13, Depth not given, Field No. 21.

*TF-678*, Chalcolithic Culture, 3530 ± 100*
*(3635 ± 100)*

Charcoal from Trench KTH-4, Layer 18, Depth not given, Field No. 19.

*TF-676*, Chalcolithic Culture, 3160 ± 105*
*(3255 ± 105)*

Burnt wheat grains from Trench KTH-4, Layer 14, Depth not given, Field No. 17. NaOH pretreatment was also given.

*TF-679*, Chalcolithic Culture, 3155 ± 130*
*(3250 ± 135)*

Charcoal from Trench KTH-3, Layer 9, Depth not given, Field No. 20.

*Sonegaon, Maharashtra, India*

Sonegaon (Lat. 18° 39′ N., Long. 74° 5′ E.), District Poona, the site is being excavated by Dr. H. D. Sankalia, who submitted the samples. The site is culturally akin to Jorwe and Nevasa.

*TF-379, Jorwe Culture, 3150 ± 90*
*(3240 ± 95)*

Charred grain from Mound II, Layer 2 b, Depth 1·2 m., Field No. 69. Visible rootlets removed.

*TF-383, Jorwe Culture, 3185 ± 100*
*(3280 ± 100)*

Charcoal from corner of baulk-cutting, Field No. 303. NaOH pretreatment was also given.

*TF-380, Jorwe Culture, 3230 ± 105*
*(3325 ± 110)*

Charcoal from Mound II, Layer 4, Depth 1·8 m., Field No. 120. Visible rootlets removed. NaOH pretreatment was given.

*TF-382, Jorwe Culture, 3195 ± 100*
*(3290 ± 100)*

Charred wheat from Mound II, Layer 5, Depth 2·2 m., Field No. 136.

*TF-384, Jorwe Culture, 3415 ± 105*
*(3515 ± 110)*

Charcoal from Mound II, Layer 7, Depth 4·2 m., Field No. 321. Visible rootlets were hand-picked. NaOH pretreatment was also given.

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# MORPHOGENESIS OF EMBRYO IN A PARASITIC ANGIOSPERM *EXOCARPUS CUPRESSIFORMIS*

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OF late, the technique of *in vitro* culture has been profitably employed for studying seed germination and embryo morphogenesis in parasitic angiosperms. Unlike stem-parasites, root-parasites fail to germinate on simple nutrient media.[1–3] In some species of root-parasites, shoot morphogenesis has been demonstrated to be host-dependent.[4,5]

***Exocarpus cupressiformis*** Labill. is an arborescent root-parasite (Santalaceæ). Ripe fruits of the parasites were obtained from Australia through the courtesy of Professor Gwenda L. Davis. Seeds (Fig. 1, A) were excised from the fruits, washed with 1% cetri-

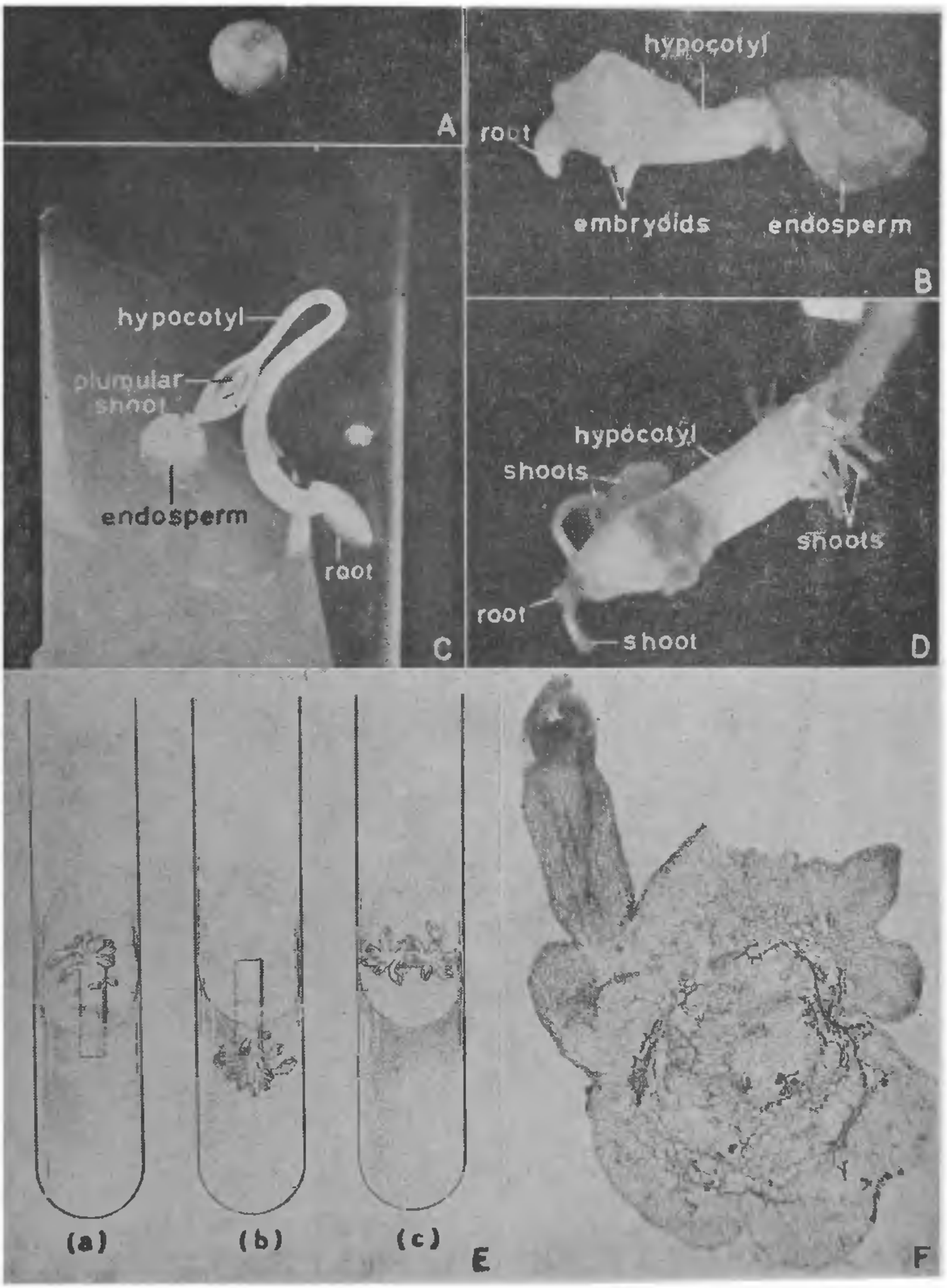


FIG. 1. A–F. A. Seed at culture, × 2·5. B. 15-week old culture on 400 ppm CH + 1 ppm IAA; the hypocotyl close to radicle has developed an arc of embryoids, of which only 2 are in view, × 9. C. Seedling formed in 15-week-old culture on WM + 400 ppm CH + 1 ppm IAA + 1 ppm Kn, plumule has developed into a small shoot, × 2·5. D. Root-hypocotyl part of axis of 15 week old seedling formed on medium as in C, × 5. E. Diagrammatic representation of polarity in differentiation of shoot-buds from hypocotyl segments; both in *a* (basal end embedded in the medium) and *b* (apical end embedded in the medium) shoot buds developed from the morphological apical end, in *c* (explants lying horizontally on the medium) shoot buds developed along the free surface of the explant. F. Transection of a 6-week-old culture of hypocotyl segments on medium as in C; note exogenous origin of the shoot-bud, × 53.

mide solution (trade name 'Cetavlon', ICI), surface sterilized with chlorine water for 10 min., thoroughly rinsed in sterile distilled water, and finally implanted under aseptic conditions on modified White's medium[6] without IAA (WM). In some experiments WM was supplemented with casein hydrolysate (CH, 400 ppm), kinetin (Kn, 1 ppm), and IAA (1 ppm), both individually and in various combinations Each experiment was repeated twice with 24 cultures each. The cultures were maintained in diffuse daylight (5-20 ft-c) at 25 ± 2° C and 50–60% relative humidity.

In Santalaceæ, the endosperm is directly surrounded by the pericarp since the integuments as well as endocarp are consumed by the endosperm. Thus, the seeds are naked. The seeds implanted on WM remained quiescent indefinitely. On WM + 400 ppm CH + 1 ppm IAA, 23% of the explants put forth the radicle in 3-week-old cultures. Whereas the radicle occasionally formed a small root, the plumule failed to develop into a shoot. In one instance, 7 embryo-like structures (embryoids) appeared on the hypocotyl close to the root (Fig. 1, B). In 19% cultures, the radicular end proliferated upon coming in contact with the culture medium. Subsequently, both roots and shoots differentiated from the proliferated mass.

With the addition of 1 ppm Kn to WM + CH + IAA, the radicle formed a short root in 25% cultures. Of the 500 cultures raised on this medium, only 5 showed the development of plumule into a shoot (Fig. 1, C). However, it remained arrested within the cotyledons. Although plumule seldom formed a shoot, differentiation of shoot-buds from endosperm[7] and hypocotyl (Fig. 1, D) occurred in 10 and 35% cultures, respectively. Besides the buds on injured seedlings (reparative buds), the hypocotyl also developed additional buds (on intact seedling).

From seedlings with *ca* 7 cm long hypocotyl, 1 cm long segments of the latter were excised and implanted on WM + CH + IAA + Kn, to study their regeneration potentiality. These were placed (*a*) vertically with the basal end (toward the radicle) embedded in the agar medium; (*b*) vertically with the apical end (toward the plumule) embedded in the medium; and (*c*) horizontally on the medium (*see* Fig. 1, E).

In the first set shoot-buds developed from the free end of the segment (Fig. 1, E, *a*) whereas, in the second set buds appeared from the end embedded in the medium (Fig. 1, E, *b*). Thus, in both sets, shoot-buds developed from the morphological apical end in strictly polar fashion. Curiously, in the third set (horizontal position), buds developed all along the upper surface of the explants (Fig. 1, E, *c*), indicating that the polarity was disturbed. Similar disturbance in polarity has been reported in experiments with stem-cuttings of willows[8,9] and root-cuttings of cabbage.[10]

Buds originated exogenously as parenchymatous outgrowths in 10-day-old cultures of hypocotyl segments. In another 4 days, these buds produced leaf primordia. The shoot-buds showed well-differentiated vasculature which was unconnected from the stele of the parent explant (Fig. 1, F).

Thus, the seeds of *E. cupressiformis*, a root-parasite, can germinate on nutrient medium in the absence of the host or host-extract. Shoot-buds, from either plumule or hypocotyl, develop only on a medium containing kinetin.

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