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Seed Dormancy and Germination of Geranium (*Pelargonium hortorum* Bailey)[1]

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Abstract. **No differences were observed in water uptake, respiration rate and seed coat morphology of 'New Era Bright Red' and 'New Era Dark Red' geranium. Water uptake in some seeds was rapid in the first 12 hours following initiation of imbibition. Radicle emergence and germination occurred 3 days after swelling and respiratory activity began as soon as seeds imbibed water. Nonswollen seeds did not germinate. Seed coat surfaces appeared wax-like in both cultivars and no relationship between occlusion of the hilum fissure and germination was observed. Dipping seed in concentrated H_2SO_4 or hot water, or removing a portion of the seed, increased germination rate and germination to nearly 100%. Results suggest the seed coat in geraniums can be impervious to water uptake.**

Availability of quality seed with rapid germination rates and high seedling vigor is paramount to successful bedding plant production. Cathey (2) established the germination requirements for a large number of ornamentals which normally germinate rapidly. However, there has been little work to improve germination rates in flowering bedding plants, since rates are generally high. Unfortunately, hybrid geranium seeds generally have poor germination unless artifically treated (J. N. Sharman, Pan American Seed Co., personal communication).

Commercial hybrid geranium production has increased in dollar value since the introduction of 'Nittany Lion' in 1964 (1, 3, 7, 8, 9). Early seed geraniums (such as the Carefree Series) were not readily accepted by growers because germination rates were low, seed was expensive, and time from sowing to flowering was longer than for vegetatively propagated plants (9). Time to flower has been reduced in new hybrid cultivars and is now similar to that of vegetatively propagated plants. Availability of plants with free branching characteristics in a wide range of flower colors and elimination of stock plants by growers have contributed to the acceptability of hybrid geraniums.

Optimum germination temperature for geranium seed is 21 to 24°C and light is not required (8, 9). Germination at these temperatures is erratic, however, with about 40% of the seeds germinating over a 21–day period. Large differences in germination rates exist in most commercially available seed unless seeds have been treated (1). These studies were conducted to determine the cause of erratic germination of hybrid geranium seeds.

Materials and Methods

Uncleaned, husked 'New Era Bright Red' (NEBR) and 'New Era Dark Red' (NEDR) hybrid geranium seeds were obtained from a commercial propagator. 'NEBR' has uniformly rapid germination rates in commercial production while 'NEDR' has slow, erratic rates. Seeds were rubbed between 2 rubber-covered boards to remove husks and stored at 18°C and 45% relative humidity. The same seed lots were used throughout this investigation.

Seed coat morphology was analyzed and compared with dehusked, commercially available seeds of 'Bright Rose Pink' (rapid germination) and 'Carefree Scarlet' (slow germination) by using a Nova Scan Scanning Electron Microscope (SEM). Seeds were oven-dried and mounted on aluminum stubs with double sided tape or Tube Coat (G. C. Electronics Co., Rockford, Ill.). Transverse sections were observed by halving seeds with a razor. Samples were sputter coated with 20–40 nm of gold-palladium and viewed at an accelerating voltage of 15 kV.

Germination rate of 'NEBR' and NEDR' was determined by placing 100 seeds in 9-cm Petri dishes with 3.5 ml double-distilled water and germinating at 25°C. Treatments were replicated 4 times. Number of seeds having a protruded radicle and plumule was counted for 29 days.

Imbibition rate of 'NEBR' and 'NEDR' was determined by placing 500 mg of seed into 9-cm Petri dishes containing 25 ml double-distilled water. Treatments were replicated 10 times. Seeds were germinated at 25°C in a completely randomized design. Seeds were removed after 4, 9, 24, 48, and 72 hr, vacuum dried for 1 min in a Buchner funnel, and weighed. The difference between original weight and weight at each time interval was attributed to imbibed water. After each weighing, seeds were reimmersed.

In a second imbibition study with 4 replications, 100 seeds of both cultivars were weighed and placed in Petri dishes, as pre-

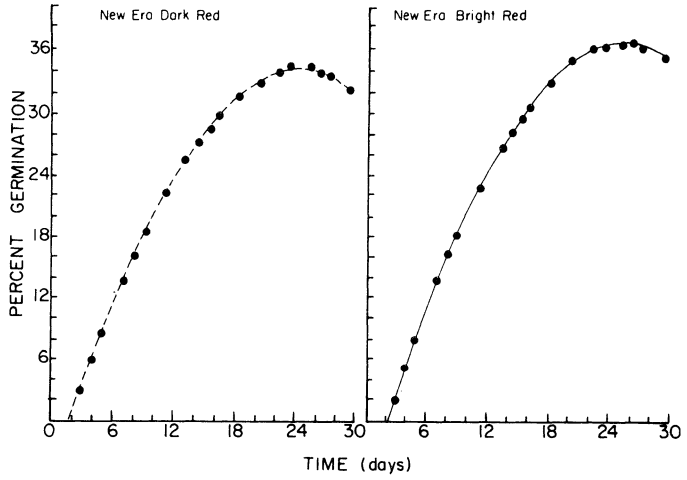

Fig. 1. Germination rate of 'New Era Dark Red' and 'New Era Bright Red' geranium seeds at 25°C in the dark.

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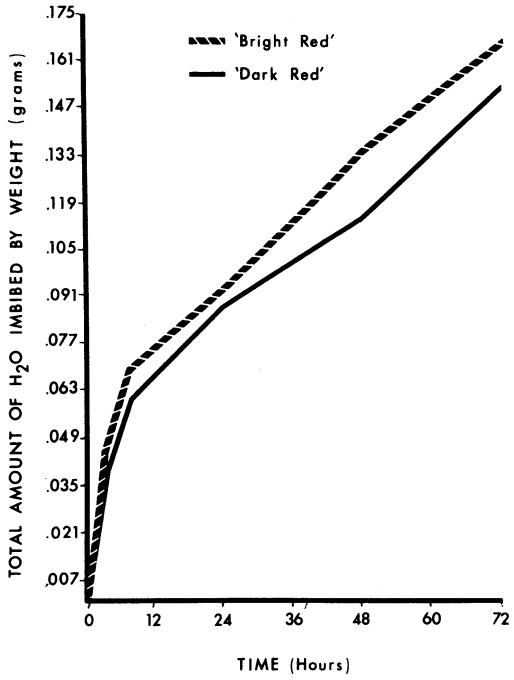

Fig. 2. Imbibition rates of 'New Era Dark Red' and 'New Era Bright Red' geranium seeds at 25°C.

viously described, to constitute a treatment. Seeds were removed from germination chambers after 6 hr, divided into imbibed (swollen) and nonimbibed (nonswollen) groups, counted and weighed. Swollen seeds were removed after 12, 24, 48, 72, 96, 120, 312 and 480 hr. Time to radicle protrusion and germination (protrusion of the plumule) were determined for imbibed seeds. Nonimbibed seeds were weighed.

Respiratory activity of seeds following initiation of imbibition

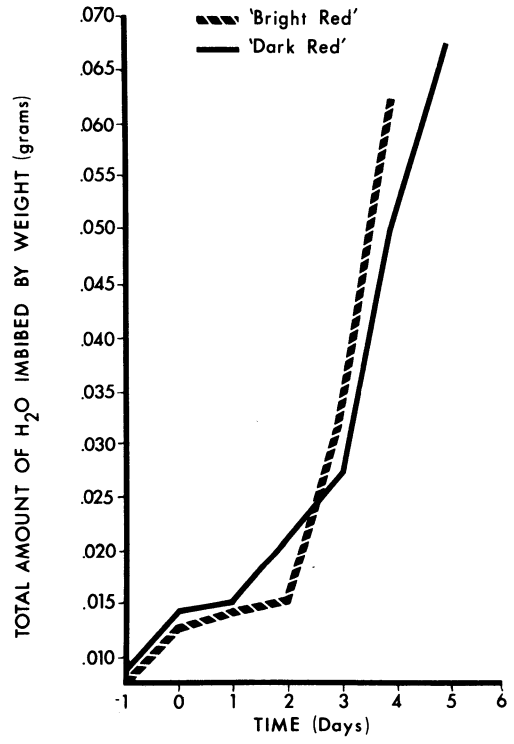

Fig. 3. Imbibition rate of swollen 'New Era Dark Red' and 'New Era Bright Red' geranium seeds at 25°C. Seeds were imbibed for 6 hr and became swollen between −1 and 0 days.

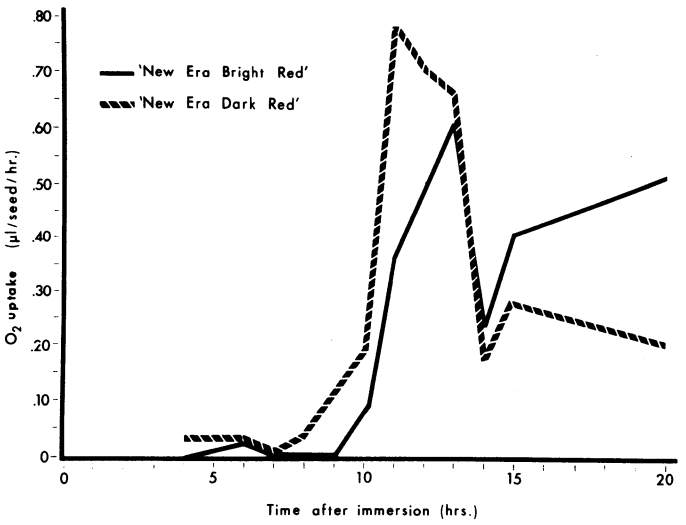

Fig. 4. Respiratory activity of 'New Era Dark Red' and 'New Era Bright Red' geranium seeds at 25°C.

was determined by placing 20 seeds of both cultivars in a respiratory flask containing 1 ml of double-distilled water. Flasks were placed in a Gilson Respirometer at 25°C and 0_2 uptake was recorded hourly from 4 to 15 hr and at 25 hr. In a separate study, respiration of imbibed and nonimbibed seeds was determined by placing seeds in a moist Petri dish at 25°C for 100 hr prior to commencement of the experiment, then measuring 0_2 uptake every 15 min for 75 min. To determine the effects on germination rate, seeds of 'NEBR' were heated in distilled water at 60°and 80°, placed in concentrated H_2SO_4 for 0, 1, 2, 5, 10, or 20 min, or the radicle end of the seed or the opposite end of the seed was removed with a razor. Seeds were then washed, redried, and germinated. There were 4 replications each consisting of 50 seeds of each cultivar.

Results and Discussion

Germination of 'NEDR' and 'NEBR' seeds was 35% each after 29 days (Fig. 1). Some seeds began to germinate 2 days after initiation of imbibition, and 2–3% germinated daily for the next 21 days. Imbibition rates were rapid for the first 12 hr after immersion (Fig. 2) and remained high throughout the experiment. There was considerable variation in the number of imbibed seeds at each weighing. Some seeds absorbed water and swelled within 12 hr, while others did not appear swollen until much later. Nonswollen seeds did not increase in fresh weight or germinate. Swollen seeds averaged 5.3 mm in length and 2.2 mm in width; nonswollen seeds were 4.2 mm long and 1.6 mm wide. These data suggest that some intact seed coats might restrict water uptake and/or gas exchange, since nonswollen seeds did not imbibe water.

Swollen seeds rapidly increased in weight immediately following imbibition (Fig. 3). Nonswollen seeds of both cultivars appeared to imbibe or absorb a small amount of water initially.

Table 1. Respiration rate of swollen and nonswollen 'New Era Bright Red' and 'New Era Dark Red' geranium seeds at 25°C.

Cultivar	Respiration (µ$l0_2$/seed·hr)[z]	
	Swollen	Nonswollen
Bright Red	1.8a[y]	0.0b
Dark Red	2.0a	0.0b

[z]means based on 6 reps. with 20 seeds/rep.
[y]means separation by LDS, 5% level.

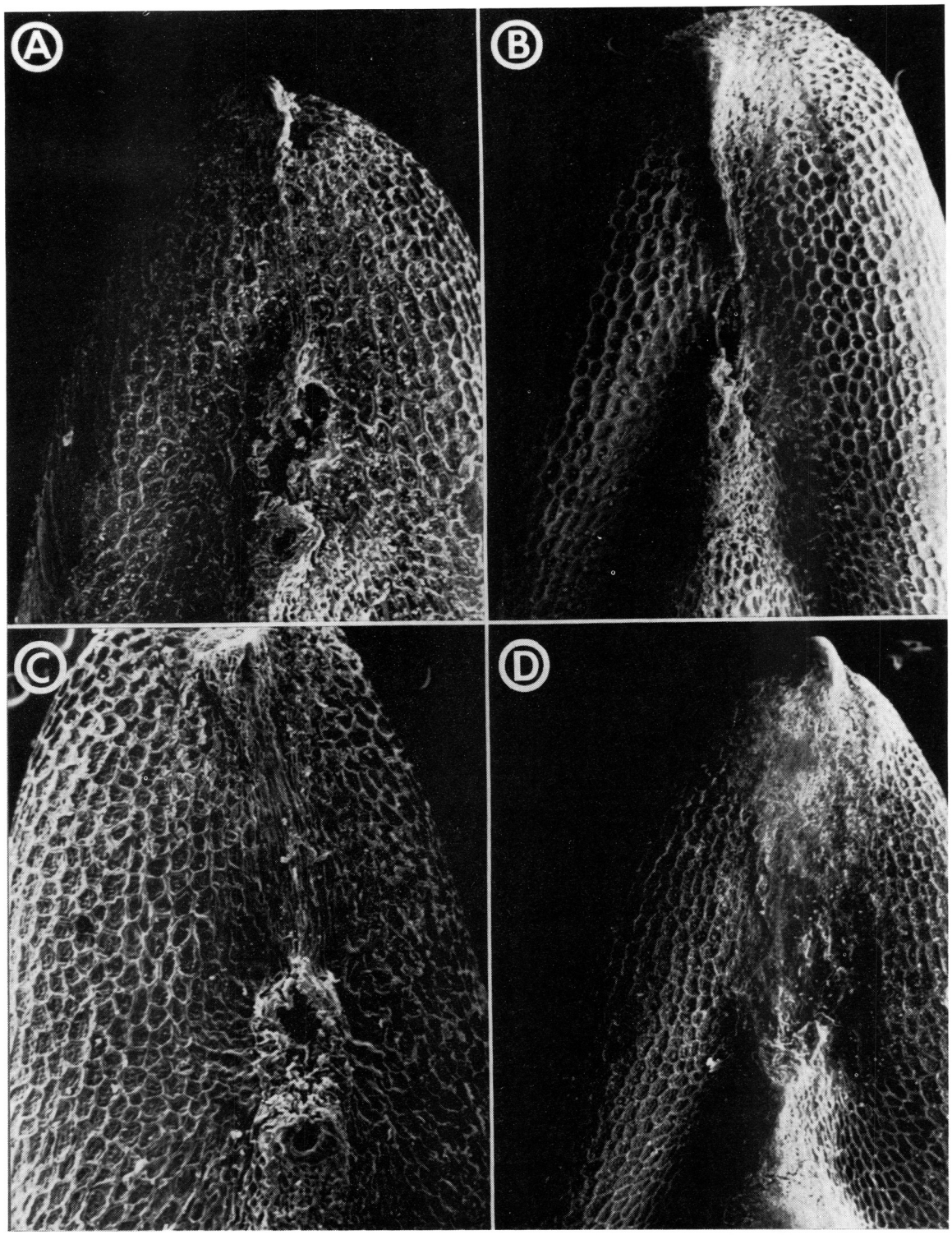

Fig. 5. Scanning electron photomicrograph of seed coat surface of geranium cultivars. A) 'New Era Bright Red'; B) 'Carefree Scarlet'; C) 'New Era Dark Red'; D) 'Bright Rose Pink'.

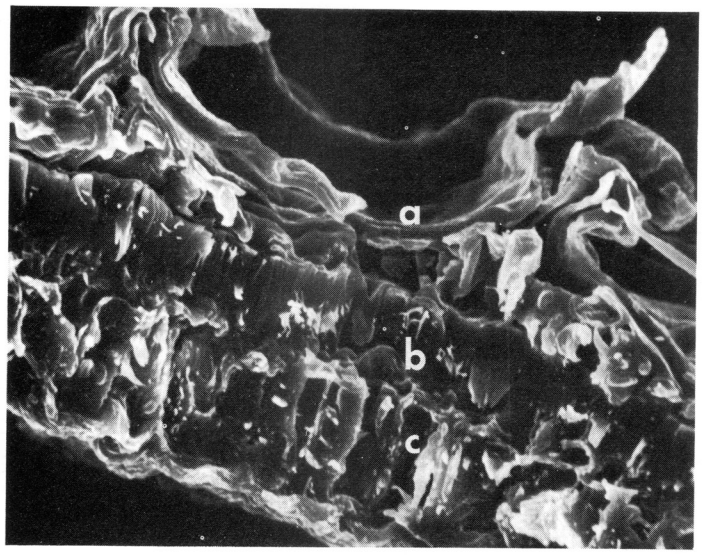

Fig. 6. Transverse view of geranium seed coat showing epidermal (a), sub-epidermal (b), and palisade (c) layers.

Swollen seeds gained 7.0 mg after 6 hr while nonswollen gained 2.5 mg. Weight of swollen seeds was maintained until germination. Only swollen seeds germinated. Germination of both cultivars was uniform once seeds became swollen. Radicle emergence in both cvs occurred 3 days after swelling with protrusion of the plumule 1 or 2 days later in 'NEBR' and 'NEDR', respectively.

Increased respiratory activity of a 20-seed sample was observed 7–10 hr after immersion (Fig. 4). Oxygen uptake increased from 0–0.18 μl/seed·hr from immersion to 10 hr with levels generally increasing after this time. Erratic swelling of individual seeds led to variability in respiratory activity throughout the experiment. Swollen seeds accounted for the respiratory activity noted above with respiration levels up to 2.0 μl 0_2/seed·hr (Table 1). Nonswollen seeds did not respire. Nondormant swollen seeds respired and germinated once imbibition was initiated (6). Therefore, restriction of 0_2 supply, which is characteristic of some seeds with hard seed coats (4), was not characteristic of geranium, since once imbibition occurred, respiration rate increased.

The seed coat consisted of 3 layers with the outer layer appearing wax-like (Fig. 6). The outer epidermal layer was composed of connecting ridges of wax-like material arranged in circular form (Fig. 5). The epidermis or the subepidermal and palisade layers may each impose a barrier to imbibition. Large cracks in the seed coat of various cultivars having high germination rates were not obvious. The hilum fissure was prominent in 'NEDR' and 'NEBR', whereas the hilum appeared occluded in 'Bright Rose Pink' and 'Carefree Scarlet' (Fig. 6). No relationship between hilum morphology and germination was apparent.

Germination of 'NEBR' seeds increased to 98% after a 5-min dip in H_2SO_4 (Fig. 7). If dipping times were less than 5 min, seedlings were abnormal. Longer treatment decreased germination and killed the seeds. Similar germination was obtained when the seed end opposite the radicle was removed. Removal of the radicle end led to abnormal seedling growth since the radicle was generally severed from the cotyledon. Germination also improved when seeds were placed in hot (60°C) water for 20 min, but improvement was not as great as with H_2SO_4 (Fig. 7). Dangers associated with the use of H_2SO_4 and the care required to remove a portion of the seed coat make this treatment undesirable commercially. Harsh scarification treatments such as sandpaper or grinding with sharp sand commonly result in injury to the radicle and abnormal seedlings.

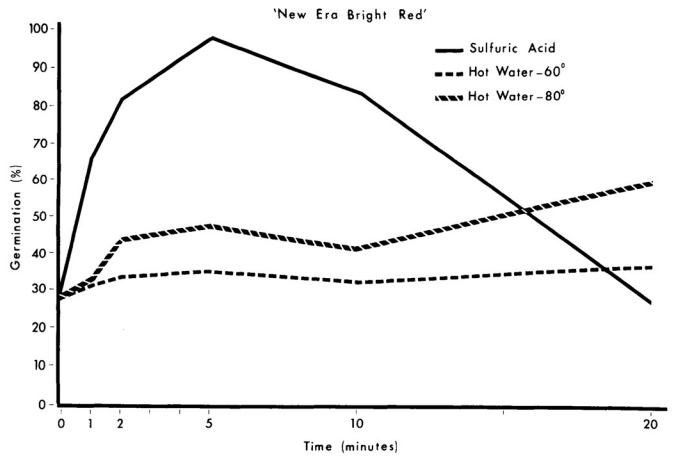

Fig. 7. Germination of 'New Era Dark Red' and 'New Era Bright Red' seeds at 25°C following treatment with H_2SO_4 and hot water.

This study indicates that the intact seed coat of geranium can act as a barrier to water uptake. Some seeds imbibe water immediately, become swollen and germinate while others do not unless scarified through tip removal. Differences in seed coat hardness may occur during seed ripening (5). Geranium seeds are ripened on the mother plant and are collected after all seeds have shattered. Individual seeds may be subjected to changes in environmental conditions during the prolonged period of shattering.

The hilum fissure plays an important role in controlling seed hardness in certain legumes (5), acting as a hygroscopic valve allowing seeds to dry during periods of low relative humidity, but preventing moisture gain under high humidity. Therefore, seed moisture content is determined by the lowest relative humidity during ripening, and the lower the seed moisture content the harder the seeds become. The hilum becomes permanently closed when seed moisture content is low and moisture cannot penetrate the hard seed coat. Possibly, the prominent hilum in geranium seeds may close in early-matured seeds prior to seed harvesting, whereas it is partially open in the later-maturing seeds. If the hilum valve is nonfunctional and does not close entirely water could penetrate the seed. Hot water may partially open the hilum, enabling imbibition to occur. Additional research is needed to identify the role of the hilum valve in geranium seed hardness.

Germination characteristics of 'NEDR' and 'NEBR' observed in commercial production cannot be explained by our data. Seeds of 'NEDR' may be less vigorous than 'NEDR' and become nonviable more rapidly than those of 'NEBR' if not properly handled prior to sowing or may be more susceptible to pathogenic organisms. These results indicate, however, that poor germination is caused by the seed coat restricting imbibition of water. Continued work is needed to determine methods of eliminating poor germination in geranium seeds and to develop a practical means of overcoming existing germination problems without injuring the seedling.

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Scanning Electron Microscope Examination of Flower Bud Differentiation in Sour Cherry[1]

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Additional index words. Prunus cerasus, flower primordia

Abstract. **Axillary buds on 'Montmorency' sour cherry (*Prunus cerasus* L.) shoots were examined by scanning electron microscopy. On June 10, 4 weeks after anthesis, a doming of the apex signified the initial change from the vegetative to the reproductive stage. Flower primordia differentiated acropetally in the axils of bracts between late June and mid-July. Bract and flower primordia formed until all available space on the apex was occupied. Flower primordia changed from ovate to round as development proceeded. Sepal primordia were evident on July 30, 11 weeks after anthesis, and petal primordia had formed by August 15. Concentric rings of stamen primordia then developed followed by carpel differentiation in early September.**

Morphological changes during flower initiation in fruit trees have been described at the light microscope level (3, 5, 6, 9) using stained median longitudinal or transverse bud sections. Studies of flower development in Easter lily (1), carnation (4), grape (7), plum (9), and *Saururus cernuus* (8) have demonstrated the value of the scanning electron microscope (SEM) in studying flower development. Goff (5) reported that the first visible sign of flower initiation in sour cherry occurred 5–6 weeks after anthesis and differentiation of most flower parts was complete 8–10 weeks later. Timing varied with location and tree vigor. Inflorescences contained 2 to 4 (occasionally 5) flowers arranged in a corymb (5). This study describes the morphological changes at the apex of axillary buds of sour cherry shoots during flower formation as determined by SEM.

Materials and Methods

Buds from 18-year-old 'Montmorency' sour cherry trees in a productive commercial orchard at Mears, Mich., were collected periodically between June 10 and September 29, 1976 (anthesis on May 10). Fifty buds were collected at each sampling date from 10 trees uniform in size and vigor. After removal of outer bud scales, buds were placed in distilled water, then dehydrated using a 10-step graded ethanol series (10 to 100%) within 24 hr of sampling, allowing at least 20 min in each solution. After 3 changes of 100% ethanol, samples were critical-point dried and stored in a desiccator over anhydrous $CaSO_4$. Dehydrated buds were further dissected under a stereo light microscope to expose the floral primordia. The apices were mounted on aluminum SEM stubs using 'Tube Coat' (G. C. Electronics Co., Rockford, Ill.), sputter coated with 40–60 nm of gold, and viewed with a Super II SEM (International Scientific Instrument Co.) at 15 kV.

Our observations indicated that flower development in axillary buds on current season wood was similar to that in buds on spurs of 2-, 3-, or 4-year-old wood; the former were used because they were easier to dissect. At least 10 apices were examined at each sampling date.

Results and Discussion

Table 1 summarizes all observations, and Fig. 1 illustrates selected stages of development. Vegetative apices of deciduous fruit trees possess a smooth, rounded crown of meristematic tissue nearly enclosed by primoridal leaves, bracts, or bud scales (3, 5, 9). Flattening of the apex, marking the change from the vegetative to the reproductive phase, had occurred by June 10, 4 weeks after anthesis (Fig. 1A). The meristem in apices collected 5 days later had flattened considerably, and bract primodia were evident (Fig. 1B). Other primordia subsequently differentiated in a spiral pattern. The youngest bract primordium occurred near the center of the meristem, indicating an acropetal or centripetal pattern of differentiation. Individual flower primordia had initially formed in the axils of bracts by June 28 (Table 1, Fig. 1C), and continued to develop (Figs. 1D, E).

On July 3, flower primordia were ovate (Table 1), becoming rounded one week later (Fig. 1D). Primordia were nearly surrounded by bracts at this time, and occupied most of the space on the apex by July 20 (Table 1). On July 30, sepal primordia were evident in a pentagonal whorl (Fig. 1E). The rounded apices of the flower primordia gradually became concave (6). Petal primordia and some stamen primordia were evident on August 15 (Table 1). Differences in stage of organogenesis between flowers within buds were apparent in early September: some had large stamens; other had not differentiated petal primordia. On September 29, the carpel primordium had been initiated within the floral cup (Fig. 1F).

Most reproductive apices produced 3–4 flowers, the number apparently being determined by apex size, which allowed development of only a certain number of bract primordia. In some buds, even though a 4th or 5th bract primordium differentiated, the flower in its axil developed slowly if at all. Stage of development differed among flowers within a given bud until anther and/or carpel initiation, after which all flowers appeared similar. Tetrad formation in the anthers consistently occurred 2 days earlier in the first flower to open, while embryo sac degeneration was significantly more frequent in the third (2). Furthermore, the third flower to open had a lower fruit-setting potential than did the first

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