inheritance (7, 16), were tested and found to be acceptable fits (Table 5). This suggests that the genotype of MSU 2A is $AA\ acr^+\ acr^+$ with monoecious expression. Further studies of crosses between MSU 2A and androecious lines would be necessary to determine genetic differences.

Deviations from expected F_2 ratios occured with 'Tablegreen 68G' crosses and progenies (Tables 2 to 4). In the case of 'Tablegreen 68G' × MSU 1A1 (East Lansing), a higher than expected female tendency was noted; that is, more gynoecious and PF phenotypes. A high percentage of gynoecious segregates were observed in other generations of this cross as well. Varying intensities of femaleness among "gynoecious" lines has been reported previously (7, 8, 16). Moreover, 'Tablegreen 68G' expresses intense femaleness and is difficult to induce male flowers after treatment with GA4/7 (unpublished data).

In the F_2 of MSU 394G × MSU 1A1 and MSU 394G × MSU 1A2 (East Lansing location), the significant deviations result from a higher than expected frequency of continuous pistillate plants. A high female intensity is evident in other crosses with MSU 394G (Tables 2 to 5). The possibility of a unique environmental effect on the F_2 populations of both MSU 394G × 1A2 (East Lansing) and Tablegreen 68G × MSU 1A1 (East Lansing) is apparent since the same pedigrees at the Sodus location were consistent with the expected ratio.

The possibility of using androecious lines as pollinators for the production of hybrid seed is appealing. For hybrid seed production an androecious pollinator would be used in a manner similar to monoecious pollinators (11, 14) resulting in highly female F_1 cultivars. On the other hand, hermaphroditic lines seem more suitable as pollinators for seed production of all-gynoecious F_1 cultivars (5, 12) necessary for parthenocarpic cucumber production (12).

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Abnormalities in Seed Development in *Pistacia vera* L.[1]

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Abstract. In the pistachio cv. Kerman an average of 26% of the fruits contain no seeds or only poorly developed ones at maturity. A study of aberrations revealed; a) pollen tubes sometimes entered the embryo sacs at the chalazal end (the pistachio is chalazogamous), which may result in eventual degeneration of endosperm or zygote nuclei; b) frequent degeneration of zygote (or egg) or young endosperm nuclei from unknown causes; c) occurrence of a brown spot on the funiculus of many young seeds in some years, the necrosis usually spreading to the embryo sac; d) and hypertrophy of nucellar cells in some older seeds was frequently accompanied by proliferation of other nucellar cells, both limiting development of embryo and endoperm. In cv. Bronte a frequent aberration is protrusion of endosperm or embryo through a greatly distended endostome.

In *Pistacia vera* L. numerous female flowers and young fruits abscise. In addition, various percentages of the nuts that set and remain on the trees to maturity contain no seeds, or only underdeveloped ones. An average of about 26% of the nuts in 'Kerman' are seedless, a portion of which is due to parthenocarpy (2). Degeneration of megaspore mother cells or megaspores and embryo sac degeneration are abnormalities which Grundwag and Fahn (3) found in *P. vera* trees of unknown origin. Since pistachio may become an important crop in CA, events leading to interrupted seed development in 2 cultivars were investigated.

Materials and Methods

Female inflorescences of 'Kerman' were collected from the Wolfskill Experimental Orchard, Winters, CA, at weekly intervals after full bloom (April 22). Flowers, young fruits, and seeds were fixed in

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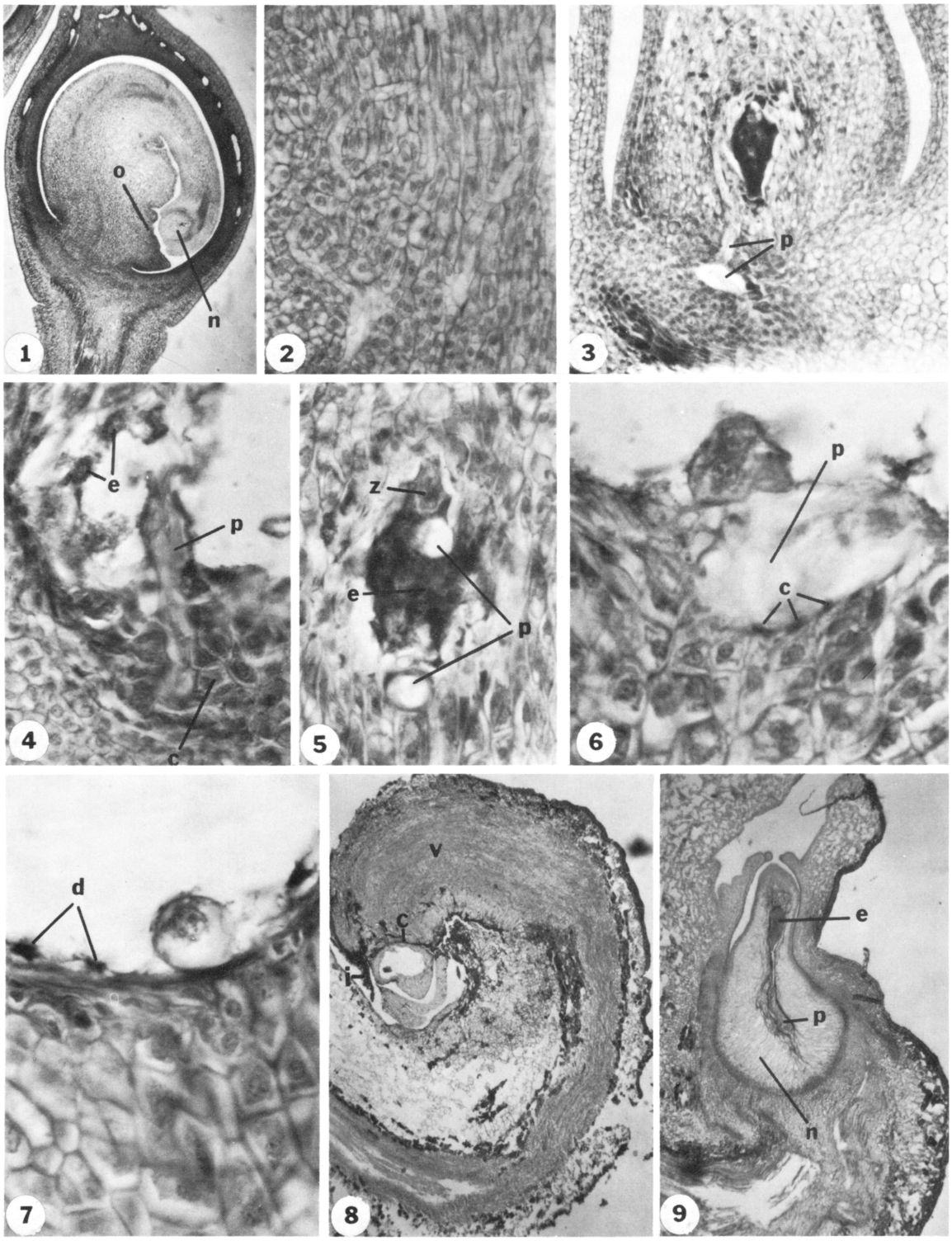
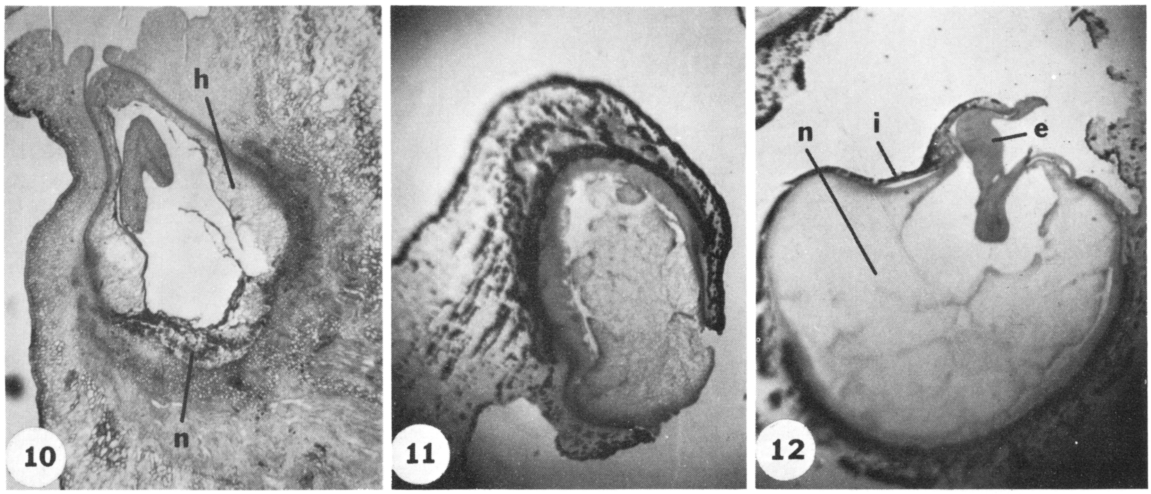


Figs. 1–9. Normal and abnormal features in seed development in *Pistacia vera* cv. Kerman. Fig. 1. Longisection through an ovary (stylar end at the top) and the ovule. Note the curvature of the funiculus and its thickened base, the obturator (o) which faces the tips of the nucellus (n) and integuments, and the embryo sac shown as a tiny black spot deep in the nucellus; collected 4/22. ×20. Fig. 2. Parts of 2 pollen tubes in the funiculus; collected 5/12. ×320. Fig. 3. Normal path of the pollen tube (p) around one side of the embryo sac to the micropyle. The diameter of a pollen tube may change greatly when it changes direction, as in this case; collected 5/5. ×160. Fig. 4. End of a pollen tube (p) which has penetrated the chalazal end of the embryo sac. Some of the discharged contents are seen above the tube. Presence of endosperm nuclei (e) indicates that fertilization had occurred. The tissue (c) surrounding the pollen tube was formed by proliferation of the integumentary tapetum; collected 5/26. ×640. Fig. 5. An embryo sac which was entered at the side by a pollen tube (p) 1 cross section of which is seen just below the sac and another appears in the sac just below the zygote (z). Several endosperm nuclei (e) are evident; collected 5/5. ×480. Fig. 6. Swollen part of a pollen tube (p) in nucellar tissue adjacent to the embryo sac. The presence of the young proembryo above it is evidence the tube had remained there for the 5 weeks that usually elapse between pollination and division of the zygote. Just below the tube are the remains of 3 cells it crushed (c) along its course; collected 5/26. ×960. Fig. 7. A zygote and 3 degenerating endosperm nuclei, 2 labeled "d;" collected 5/26. ×960. Fig. 8. Effects of a small necrotic spot formed on one side of the funiculus early in development. At the time of collection (6/16), necrosis had spread to the outer integument (i), the chalaza (c) and adjacent tissue. Embryo sac structures had degenerated and been absorbed. Cell proliferation in the upper part of the vascular bundle (v) caused considerable increase in diameter of the bundle and also eliminated the typical large resin ducts in the vascular tissue. ×26. Fig. 9. Longisection of a seed containing a



Figs. 10–12. Aberrations in seed development in *Pistacia vera* L. Fig. 10. Longisection of a seed of *P. vera* cv. Kerman in which the embryo is under-developed and the endosperm has been completely absorbed. The embryo measured approximately 0.75 mm, while a normal one collected on the same date measured 13 mm. Nucellar cells on the side of the embryo sac had hypertrophied (h), while those at the base proliferated and some regions developed necrosis (n); collected 8/11. ×26. Figs. 11 and 12. Longisections of seeds of 'Bronte'. Fig. 11. Protrusion of the endosperm through torn integuments; collected 8/8/ ×8. Fig. 12. The malformed embryo (e) protruded through the stretched and ruptured integuments (i). The endosperm, formed as a mass of lobes of various shapes and sizes, was still mitotically active in the peripheral, more deeply stained layers; in normal ovules mitosis had ceased some weeks before; collected 8/11. ×12.

Randolph's solution or formalin-propionic acid-70% ethanol (1:1:18 v/v/v). They were dehydrated in a tertiary butyl alcohol series or in tetrahydrofuran (5), embedded in paraffin, sectioned at 10 μ and stained with haematoxylin-fast green with or without addition of safranin. Specimens of 'Bronte' from a commercial orchard in Elk Grove, CA, were also processed in the same manner.

Results and Discussion

The embryology of *Pistacia* is unusual. As shown by Jones (4), Copeland (1), and Grundwag and Fahn (3), during the development of the ovule the basifixed funiculus greatly elongates and curves in about a 360° arc (Fig. 1). Jones (4) described the ovule as being orthotropous, whereas Grundwag and Fahn (3) considered it anatropous. We agree with Jones that it is orthotropous, as there is no fusion of the integument on 1 side of the ovule with part of the funiculus as in the anatropous type. A structure considered by Jones and the other authors to be an obturator develops on the funiculus near its base, facing the micropylar end of the ovule. There, protrusions and depressions develop which conform more or less to the surface outline of the ovular structures they face or partly enclose (Fig. 1). Pollen tubes might have been guided to the micropyle by these structures in an earlier phase of evolution. However, the obturator has become an obsolete organ insofar as that function is concerned, for the genus *Pistacia* is chalazogamous. After passing through the conductive tissue of style and ovary wall, the pollen tube crosses the gap between the endocarp and the arch of the funiculus, grows through the epidermis and cortex and follows the vascular tissue, often in a zigzag course, down to the chalaza. Rarely, 2 or 3 pollen tubes are found in the ovule or young seed (Fig. 2). After reaching the chalaza, the tube usually passes around the embryo sac to the region of the egg apparatus (Fig. 3), where it turns and penetrates 1 of the synergids. Sometimes, however, the pollen tube enters the chalazal end of the sac (Fig. 4) or the side of the sac (Fig. 5). The latter figure shows a cross-section of a pollen tube in the chalaza and another of the same tube inside the sac. From the chalaza, the tube apparently grew part way around the side of the sac and then turned into it. The presence of several endosperm nuclei is evidence that the tube contents were discharged in the sac. Degeneration of egg, zygote, endosperm, or of all sac structures, was noted in some of the embryo sacs that had been entered at the chalazal end or the side. Perhaps the degeneration was a consequence of the irregular entry of the pollen tube into the sac. The pollen tube sometimes causes injury to tissues it passes through, as illustrated by the deeply stained contents of cells adjacent to the tube (Fig. 6). Two of the older seeds studied contained extensive necrotic tissues in the chalaza and adjacent nucellus, which may have originated in cells injured by the pollen tubes. The injury may be increased by the swelling of some regions of pollen tubes after their growth has ceased (Figs. 2, 3, 5, and 6).

The first collection of young seeds and ovules, 11 days after full bloom, included many in which the embryo sac contents were degenerating because of lack of fertilization, as shown by the absence of pollen tubes in any of their tissues. The zygote or unfertilized ovule was degenerating but several endosperm nuclei were present in some seeds. Relatively few seeds of the first collection contained a zygote and endosperm that appeared normal. The cause of degeneration was not apparent, but it might have been competition for nutrient substances. These results explain why so many of the numerous flowers and young fruit abscise. Collections during the following month included higher proportions of normal seeds but always some in which the endosperm and/or zygotes or embryos were abortive. Figure 7 shows part of an embryo sac, including 3 degenerating endosperm nuclei and a normal zygote. In our material the zygote divides about 5 weeks after bloom, in contrast to the 10 to 12 weeks reported by Grundwag and Fahn (3).

Early in June, a number of seeds had a small necrotic spot on one side of the funiculus close to the ovule. Microscopic examination revealed that the injury was usually confined to the epidermis and outer 1 or 2 layers of cortical tissue. Necrotic tissue was more extensive both in the seeds and in funiculi of some of the seeds collected 2 weeks later. Figure 8 illustrates the general type of injury, i.e., degeneration of embryo sac structures, and necrotic tissue running through the chalaza and appearing in some regions of the integuments and funiculus. Considerable cell proliferation had occurred in the vascular bundle in the upper part of the funiculus. This increased the diameter of the bundle (cf. vascular bundle in Fig. 9) and eliminated the resin ducts that typically run through the main bundle and the branches which surround the base of the embryo sac. Extensive proliferation such as this was found in vascular bundles of several funiculi which each had a necrotic spot on the surface, and in 1 funiculus which did not. Necrotic tissue developing in the chalaza

stunted embryo (e) and devoid of endosperm. Hypertrophied cells of the nucellus (n) occupied most of the embryo sac space. The tissue below the embryo was composed of proliferating nucellar cells (p) which had pushed into the base of the sac, as seen in other sections; collected 7/7. ×26.

probably blocked the flow of nutrients to the embryo sac, and these nutrients were then used in cell proliferation in the vascular bundle. Seeds with necrotic spots were found in all subsequent fixations, i.e., through 8/11, at which time normal seeds were completely developed. In some seeds the necrosis was more advanced than indicated in Fig. 8, but in others it was less severe. In all seeds with necrosis the embryo sac sturctures had either been obliterated or only an under-developed embryo with little or no endosperm remained. Seeds with necrotic spots must have accounted for a fairly large proportion of the seedless fruits in that year and perhaps in other years in which the spots were noted. Tissue surrounding several brown spots was examined carefully to determine whether fungal hyphae or bacteria were present, but neither type of organism was seen. The cause of the brown spots might be a physiological disturbance. Their characteristic position suggests that the region affected was particularly vulnerable.

In collections in July and August, the embryos in some seeds without necrotic spots had failed to develop normally. The immediate cause seemed to be a deficiency in the quantity of endosperm, but the probable underlying cause in some cases was abnormal development of the nucellus. Instead of the nucellus gradually diminishing in quantity, as normally occurs, the cells became hypertrophied and crowded the endosperm and embryo (Fig. 9). In several embryo sacs, regions of enlarged nucellar cells were separated by regions of proliferating nucellar cells (Fig. 10). Such aberrations of nucellus and endosperm may account for the subnormal size of some seeds at maturity.

In 'Bronte' an unusual type of abnormality, which occurs in the later phases of seed development, may affect many seeds of a crop. Pressure against the integuments by the developing embryo and endosperm, particularly the latter, which appears sometimes to have developed at the expense of the embryo, causes the endostome to be greatly stretched. The inner integument or both integuments may rupture, allowing the endosperm or embryo, or both, to protrude (Figs. 11 and 12). Because of the excessive pressure on the embryo it is often malformed.

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Plant Population Studies with Pickling Cucumbers Grown for Once-over Harvest[1]

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Abstract. Cucumbers (*Cucumis sativus* L.), 'Bounty' and 'Premier', were grown at 8 population densities ranging from 50,000 plants per ha (46 x 46 cm spacing) to 850,000 plants per ha (10 x 10 cm spacing). Sections of the field were harvested once-over on 2 sampling dates. Yields as dollars per ha and as tons per ha increased with increasing plant population at densities of 50,000 to 100,000 and 250,000 to 500,000 plants per ha. Over the common commerical populations, 100,000, 150,000, 200,000 and 250,000 plants per ha, yields did not increase as population increased. Delay in harvest for 4 days did not affect dollars per ha yield but doubled the tons per ha produced. Fruit sizing was slower in higher plant populations (250,000 to 850,000 plants per ha) than in the lower plant densities (50,000 to 200,000 plants per ha). The number of fruit per plant decreased with increasing plant population. Length to diameter ratios of 'Premier' were lower at the lowest plant population, 50,000 plants per ha. L:D ratios of 'Bounty' were unaffected by plant population. Varying plant populations did not affect the percent off-shape fruit, or fruit color (green quality and uniformity) of either cultivar.

Fruits must develop uniformily for optimum yield and profit from size-graded fruit in a once-over harvested pickling cucumber crop. Plant population densities govern uniformity as well as the number of fruits produced per plant. Light, water, and nutrient availability affect yield, and all are affected by population density.

Much information has been reported on how various plant species respond to population pressure. Yields of snap bean (5), soybean (6), brussel sprouts (4), tomatoes (2, 3, 7, 9), and cucumbers (10) have been increased by planting more plants per unit area. Generally, per-plant yields decrease as plant population increases (2, 8).

Precise information regarding the response of pickling cucumbers harvested once-over to population pressure is not available. Our objective was to determine the effect of plant population on pickling cucumber yield and fruit quality.

Materials and Methods

Cucumbers (cv. Bounty and Premier) were seeded in a sandy loam soil with a Stanhay seeder. Population spacings were equidistant spacings "on the square" for all densities as outlined in Table 1. From 2–3 seeds per site were sown at each spacing then thinned to 1 plant after seedling emergence. Each plant spacing of each cultivar was replicated 5 times. Individual plots were 8 m long. Fertilizer was disked in before planting at a rate of 560 Kg/ha of 6-24-24 and 100 Kg/ha N as NH_4NO_3. Dyanap (dinoseb + naptalam) was applied immediately after seeding for weed control. Irrigation was used after the herbicide application and during fruit development to supplement rainfall. Recommended practices for disease and insect control were followed. One hive of bees per 50,000 plants was present.

Each sample plot was harvested twice by dividing the plots into 3-m sections, and allowing an additional 2 m of row for guard. The initial harvest was made 49 days after sowing when approximately 10–20% of the fruit were 4.1 cm or larger in size. The second harvest was made 4 days later. For each harvest all of the fruit was removed, graded,

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