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The Effect of Pretreatments on Avocado Seed Germination

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Summary

Avocado seeds were given various preplanting treatments. Counts of seedling germination made 33 days after planting proved to best differentiate the effects of the treatments. Compared with planting the entire seed, removing the seed coats resulted in a statistically significant increase in germination percentage, as did also slicing off the seed tips. A combination of peeling plus tip slicing resulted in a significant germination increase over peeling alone. When slices were also removed from the sides of the seeds, there was a further significant increase. The relative germination disadvantage of seeds given no pretreatment increased with time. These results are discussed in terms of the labor required to carry out each treatment, the varying danger of seed infection, and the indicated nature of the hindrance to seed germination of the avocado. (*See* **Commercial Conclusions.)**

In 1942, Eggers (3) published his discovery that in the avocado *(Persea americana* Mill.), removing the seed coats prior to planting greatly increased the rate of germination. Later (9), it was reported that cutting off the seed tips was even more effective. One or both of these treatments is now the usual practice in California, at least with seeds that have been subjected to cold storage (1, 4, 9, 16).

Avocado seed pretreatment has now been practiced also in Argentina (12), Cyprus (5), Florida (15), Israel (10), Mexico (2), Puerto Rico (8), South Africa (11), and no doubt elsewhere. The standard plant propagation text of Hartmann and Kester (7) refers to such pretreatments as accepted procedures for avocados.

However, apparently the only published comparison of different pretreatments that analyzed for statistical significance (10) had its results corrupted by disease infection. And, to our knowledge, no study has been made of the relative labor costs of the different pretreatments.

Materials and Methods

Several hundred fruits of the largely Mexican race Indio (or "Desert") variety of avocado were harvested on October 23, from the parent tree growing just west of the town of Indio in the Coachella Valley. The fruits were left at room temperature to soften. On November 2, the seeds were removed from the softened pulp; they were then placed in cold storage at 40°F (4.5°C). On November 13, the seeds were divided at random into six lots, and the following pretreatments were given:

1) Control or "check" seeds, planted intact,

2) Peeled: seed coat completely removed,
3) About 1/5 inch (½ cm) maximum cut off seed base,
4) Base cut as in #3, plus about ½ inch cut off seed apex,
5) Peeled plus apical and basal cuts as in #4,
6) As for #5, plus slices off each side as well.

These preplanting treatments will hereafter be referred to simply as the treatments, since they are the experimental differences under study. The seeds were cared for as uniformly as possible after planting.

Figure 1 shows a cross section of an avocado seed. This view is obtained by prying the cotyledons apart. The embryo usually splits unevenly between the two cotyledons; its internal regions can be examined by a longitudinal slice through the middle, as was done for the illustration. The seed is correctly oriented for planting as it hangs in the fruit on the tree. That is, the epicotyl contains the stem tip growing point that will develop into the above-ground tree. Similarly, the radicle will grow to become the tree roots. The basal cut must, of course, be carefully made to avoid any chance of injuring the radicle. The Indio seeds averaged a little less than 2 ounces (about 45 g).

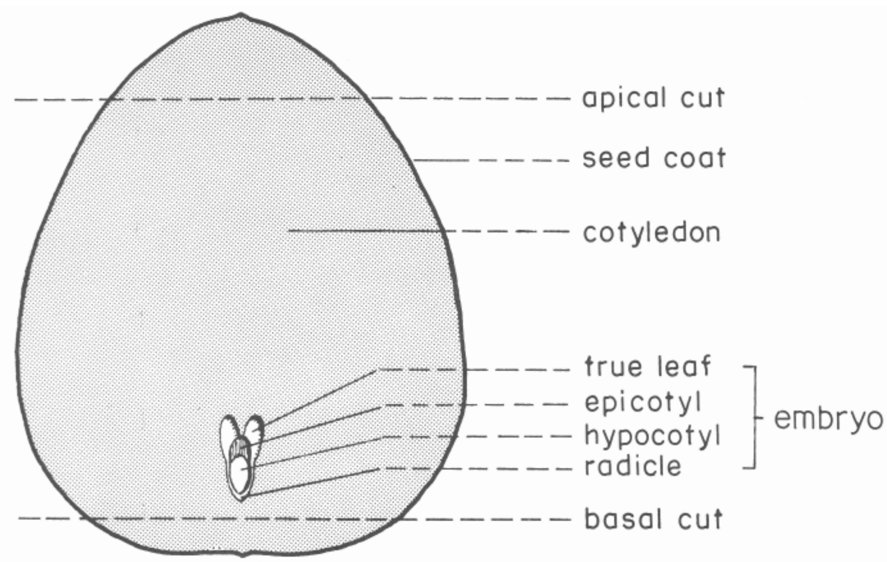

Fig. 1. Diagram of avocado seed cross section, showing the approximate location of the apical and basal slices.

Each of the six treatment groups was split up into six replications in a randomized block design. The number of seeds per treatment replication was about 20, varying in some cases because of the use of soaker pans of varying dimensions.

The germinating seedlings were observed frequently to determine the optimum date of evaluation for demonstrating treatment differences. The date selected was December 16.

Results

By December 16, a majority of the seeds given the most favorable treatment had germinated; not one seed had as yet germinated in the controls. Prior to this date, the different treatments had been gradually diverging in number of seed germinated. After that date, the number of seeds germinated for the different treatments gradually converged again, as the less effective treatments began to catch up with the more effective ones. There remained major differences in average plant height, but germination number was much simpler to work with in discriminating between treatment effects.

It had been anticipated that the treatments involving more extensive seed cutting might have an initial advantage in rate of germination, but that total germination might eventually prove to be actually lesser—since cuts permit easier entry of disease organisms. However, this was not realized. The most favorable treatment as of December 16 maintained its lead until the end of the experiment three months later, with the other treatment values converging closely behind it. When the experiment was concluded, germination had practically ceased, with a range among the different pretreatments of 73-87%. But the check seeds sprouted very slowly—even at the time of the final count less than 1% had germinated.

The results are summarized in Table 1. Statistical analysis was limited to the five treatments involving seed scarification and/or seed coat removal; no analysis is required to show that the check group is significantly different from the least effective of the other treatments, since only check replications—and all of the check replications—had zero germination. The original figures from the other five treatments were subjected to arc sine transformation because these data consisted of ratios.

Analysis of variance of the transformed values showed that treatment effects differ at the 0.001 probability level of statistical significance. A multiple range test showed that the maximum treatment, designated number six, was superior to all others at the 0.01 probability level. The 0.05 probability level (Table 1) separates the treatments into three groups of one treatment each, with the remaining two treatments statistically intermediate between the two less effective of the three distinct groups.

Table 1. Significance of the differences in seed germination among the different treatments, and the time required for each treatment.

Treatment	Germination %[a]	Treatment time[c]
1) Checks	0.0_w[b]	0.0
2) Peeled only	19.4_x	16.4
3) Basal cut	25.2_{xy}	5.6
4) Basal plus apical cut	30.7_{xy}	7.6
5) #4 plus peeled	39.6_y	13.6
6) #5 plus side cuts	70.9_z	21.8

[a]Average of all replications at 33 days after planting.

[b]Significance class, by Duncan's multiple range test, 0.05 level; percentages with the same subscript letter are not different to a statistically significant degree.

[c]Average time, in seconds, required to treat one seed.

Discussion

Treatment Differences. The results in Table 1 show that each of the five seed treatments resulted in statistically highly significant increases in seed germination when compared with the control group. The check plants were even more conspicuously delayed in germination at the conclusion of the experiment, but data were analyzed from an earlier date since it gave better separation of the various treatments.

The full treatment, numbered 6, was more effective than any of the others to a highly significant degree. The next most nearly complete treatment, numbered 5, was also the next most effective; both of these treatments gave results significantly superior to those from peeling alone (Table 1). Treatments involving bottom cuts only and bottom plus top cuts were intermediate in effectiveness between the treatments of peeling alone and peeling plus both cuts, and not distinguishable in terms of statistical significance.

Thus, after 11 days of storage, germination was markedly advanced by removing the seed coat. Cutting slices off the seed markedly advanced germination further; the more the cuts, the more rapid, uniform, and complete the germination.

Halma and Frolich (6) also reported that cutting off both seed ends proved superior to removing the seed coat. But seed coat removal alone has been recommended in Florida (15) and in Puerto Rico (8). In South Africa (11), it has been found that seed coat removal is desirable for all types of seed, but that cutting is useful only for seeds that have been stored for some time. In California also, seed cutting has been considered efficacious only for stored seeds (9), although apparently sometimes useful also on fresh seeds of at least the Guatemalan race (6).

After just 24 hours of chilling, Kadman (10) in Israel got benefit from seed coat removal similar to ours. His results differed from ours in that any seed cutting reduced germination below that of peeling alone; in fact, more severe cutting reduced germination still further. As he notes, this decline was "probably due to the penetration of various decay organisms into the embryo...", which could be greatly promoted by seed cuts. For both control seeds and seed with their coats removed, his germination percentages are quite similar to ours over the one to three months that data were collected in both experiments. Had he not had disease infestation, presumably he would have found benefits from seed cutting similar to ours.

Labor costs. In terms of relative length of time required for the different treatments, Table 1 shows that the most effective treatment, number 6, also required the greatest amount of labor. The least effective of these pretreatments, number 2, was next most labor costly, because merely removing the seed coats proved to be more time-consuming than when their removal was expedited by top and bottom cuts. However, with propagation on a commercial scale, seed coats can doubtless be much more quickly removed by the method of soaking plus rapid drying (7, 15). The latter method is not as useful for small lots of experimental seeds.

The results from the treatments involving slicing, numbered 3 and 4, demonstrate that very little treatment time per seed was necessary to obtain greatly increased germination. The results in Table 1 were those just 33 days after seed planting. At that date, the data were most discriminative among treatment effects. But by 12 days after that date, December 28, the slicing treatments had both achieved over 70% germination. This was only a little below the germination of number 6 treatment, which required several times as much labor to carry out. In contrast, only one control seed out of a total of 109 had germinated at the time of the final count nearly two months later.

Commercial Conclusions:

What can the commercial propagator conclude from these various and sometimes contradictory recommendations?

1) For seed that has been in cool storage, some preplant treatment is necessary for decent germination.

2) Removing only the seed coat is the safest treatment when there is risk of disease infection, and should have low labor costs by soaking plus rapid drying. De-seeding before the fruits are ripe usually removes the seed coat, but risks breaking the seed in half.

3) Where faster germination is wanted (or maximum germination is needed because of high seed price), seeds should be cut. Nipping off top and bottom can be done quickly (Table 1) and facilitates seed coat removal. Adding side cuts gives added benefits. There may be quicker ways to do it; possibly a machine could be designed to do the job cheaper. Cutting the seeds increases the need for thorough

fungicidal soaking.

4) With fresh, non-chilled seeds there is more uncertainty. Routine seed cutting should be practiced only when there is positive disease control. Even so, cutting may have no benefit. The propagator might test his particular seed source, under his particular conditions, over two or three years. Whichever way he decides, it would be well to run a small sample with the contrasted treatment each year.

5) Finally, it is possible that shocks to the seed apart from chilling— excess drying out, for example—may induce a more dormant state, which may call for treatment as needed by cool-stored seeds.

The Source of the Germination block.

Two major types of germination blockage are known: mechanical barriers and biochemical inhibitors. Supporting the latter explanation for the avocado is the finding (13) that ethyl alcohol extracts of avocado seed coats contained apparent auxin-inhibitor complexes, which markedly reduced tomato seed germination and also caused both split-pea-stem curvature and reduction in growth of avocado stems. Chromatic separation suggested that the complexes might be related to 3-indoleacetic acid. This biochemical-inhibition hypothesis is also supported by observation (11) that "even small adhering pieces of this seed coat may delay germination." However, the isolation of a demonstrated inhibitor from seed coats (or other plant parts) is no proof that it actually acts as such in real life *("in vivo").*

Conversely, evidence to support the mechanical barrier hypothesis comes from observations like those of George A. Zentmyer (private communication): Mexicola seeds planted in paired comparison that had embryos with cracked but attached seed coats germinated better in every replication than seeds with intact coats, the increase ranging up to 100%. The cracks could permit easier entrance of water or oxygen or release of carbon dioxide (14). However, it is conceivable that the cracks merely permitted faster leaching out of the hypothesized biochemical inhibitor.

Our own results are similarly ambiguous. Major benefit of removing the seed coat alone fits with either interpretation. Added major benefits for slicing off cotyledon pieces likewise can be argued either way. The seed mutilation could break unrecognized physical barriers, possibly invisible films at or near the seed surface, that reasonably could develop from chilling or other shock. On the other hand, the cuts could remove a biochemical inhibitor that had moved from the seed coats into outer regions of the cotyledons, perhaps assisted by chilling shock. This might explain why it has sometimes been found desirable to remove the coats from seeds of any age, but that seed cutting was beneficial only to stored seeds. Or, both explanations may be incorrect, or at least incomplete: the mutilation could result in physiological stimulus apart from our two hypotheses.

The available evidence, from the literature and from our results, is not able to distinguish between competing hypothetical explanations. There may be a combination of causes; there may be more complex interactions.

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