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J. Amer. Soc. Hort. Sci. 106(3):385–389. 1981.

Germination Studies of Clay-coated Sweet Pepper Seeds[1]

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Additional index words. Capsicum annuum, pelleted seeds, oxygen requirement

Abstract. **Seed germination of sweet pepper (*Capsicum annuum* L.) is inhibited after the seed is coated. The inhibitory effect of pellet-coating of 'Early Calwonder' pepper seed was caused by the physical properties of the coating materials. Clay coating limited part of the oxygen (O_2) from reaching the germinating seed and provided a mechanical barrier to protrusion of the radicle. Clay-coated pepper seed germinated satisfactorily on filter paper in a high O_2 environment or with minimum moisture on agar. Pellet coating formulations which would provide more O_2 to the imbibing seed would assure comparable germination of raw and coated sweet pepper seed.**

Coated seeds are widely used in the production of field, vegetable, and ornamental crops. The use of coating is advantageous in seeding small seeds (tobacco, begonia) and seeds which are morphologically unrounded, elongated, or pointed (lettuce, celery). The availability of coated seeds contributed to the development of the current procedures for precision seeding of various crops in field and nursery operations.

Based on earlier work (1, 13) and their own findings, Millier and Sooter (9) concluded that the inherent problems with the commercially available pelleted seed, compared to raw seed, are reduction in the germination rate and lowering of total seedling emergence. However, recent studies showed that most pelleted seed at present gives as good seedling emergence as does raw seed, and total emergence and coefficient of variability of seedling weights are equal for coated and raw seeds (5, 11). Although coated seeds emerge somewhat later than raw seeds, it is with no apparent sacrifice in overall performance of the crop tested and does not reduce yields (3, 6, 10).

When Bell-type pepper seeds are coated they do not germinate properly, and therefore pelleted sweet pepper seeds are not used by growers. The current study was undertaken to determine the cause of the loss of germinability of coated sweet peper seeds.

Materials and Methods

'Early Calwonder' pepper seeds were germinated in 6-cm Petri dishes, at 25 ± 1°C (2) on Whatman #3 filter paper to which 2 ml of deionized H_20 was added. The seeds were germinated in the

[1]Received for publication January 10, 1981. Florida Agricultural Experiment Station Journal Series No. 2860. The research was supported in part by a grant from Speedling, Inc., Sun City, Fla.

The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

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dark, but daily counts were performed in the laboratory under light. A seed was considered as germinated at the first sign of radicle protrusion. Germination of clay-coated seed could be recorded only 12–24 hr after actual radicle protrusion through the seed coat. The course of germination was plotted graphically and the values "P" (final percentage), "S" (time in days till germination had reached P/6), and "R" (rate in percent per day between P/6 and 5P/6) were calculated from the curve (4).

All treatments consisted of 4 replicates of 25 or 30 seeds each. All experiments were repeated at least twice. Raw seeds (Asgrow Seed Co. Kolamazoo, Mich.) were pelleted by Moran Seeds, Inc., Salinas, Calif. All seeds used in this study originated from the same seed lot.

In experiments in which the effect of high-oxygen environment was tested, open Petri dishes with seeds were placed in 450-ml sealed glass jars. One layer of 6-mm glass beads and 5 ml of H_20 on the bottom of each jar ensured high humidity. The jars were opened daily to permit seed counting. The sealed jars were flushed daily with 10–15 volumes of compressed 0_2 or compressed air via rubber septums in the cover of the jars. Internal gaseous pressure in the jar was the same as atmospheric pressure at all times, except for the flushing periods (6–8 min.)

In preparations for scanning electron microscope observations, whole coated and raw pepper seeds were mounted on aluminum stubs with double sided tape or tube coat (G. C. Electronics Co., Rockford, Ill.), oven dried at 70°C overnight, then sputter-coated with 600 nm of gold-palladium. Specimens were viewed in an Hitachi scanning electron microscope (SEM), model S-450, using an accelerating voltage of 20 Kv. Seed cross sections were prepared by halving non-oven dried seeds with a single edge razor blade and were viewed immediately.

Results and Discussion

The final percentage of the germination at 25°C of raw vs. coated seed was very similar (95 and 93%, respectively), whereas the start of the germination and the rate of germination were highly different (Fig. 1). Raw seed started to germinate within 2.4 days with a rate of 46% per day and coated seed within 12.2 days with a rate of 8% per day.

When raw pepper seeds were germinated at 25°C in the presence of coating materials (25 raw seed with the clay material removed from 25 coated seed, in each replicate), germination characteristics were very similar to those of the control raw seeds (Fig. 2). Thus, the coating material exerted no inhibitory effect on germination. The rate of germination of decoated seeds was slightly lower compared to raw seeds (41% vs. 32% per day, respectively). The latter differences were consistent in 3 separate experiments, though not statistically significant. Pepper seed has a relatively large micropylar cavity (Fig. 3-A) through which the radicle protrudes during germination (Fig. 3-B,C). After decoating, some clay still remained within the micropylar cavity (Fig. 3-D). Possibly the small delay in germination (compared to raw seed) was caused by the residue of coating materials remaining in the cavity situated above the radicle.

The decreased rate of germination brought about by coating pepper seed might have resulted from an interference with O_2 diffusion through the coating material to the embryo. In the presence of high O_2, raw pepper seed germinated about 1 day faster than seeds which were germinated in air. When germinated in O_2, coated seeds germinated as rapidly as raw seed in air and 20 to 24 days earlier than coated seeds germinated in air (Fig. 4).

When 'Early Calwonder' seed was transferred from air to a 100% O_2 environment (on the 4th, 8th, or 12th day after initiation of imbibition) it was found that the high O_2 brought about rapid release of the "low oxygen inhibited germination" (Fig. 5). The high O_2 effect was not immediate, and germination started only 2 days after transfer of the seed from air to the high O_2 environment.

High O_2 treatment exerts its effect only through a continuous exposure to the seed. Short-term exposure (up to 12 hr) at different times within the first 10 days of imbibition had no effect on germination of the clay-coated seed (data not presented). When coated seeds were imbibed in a high O_2 environment for 1 day, then transferred to air, germination was the same as in continuous air (Fig. 6). After 2 days in high O_2, before transfer to air, germination was initiated rapidly in approximately 40% of the seeds. A 3-day or longer exposure to high O_2 resulted in rapid germination of all the viable coated seeds upon transfer to air.

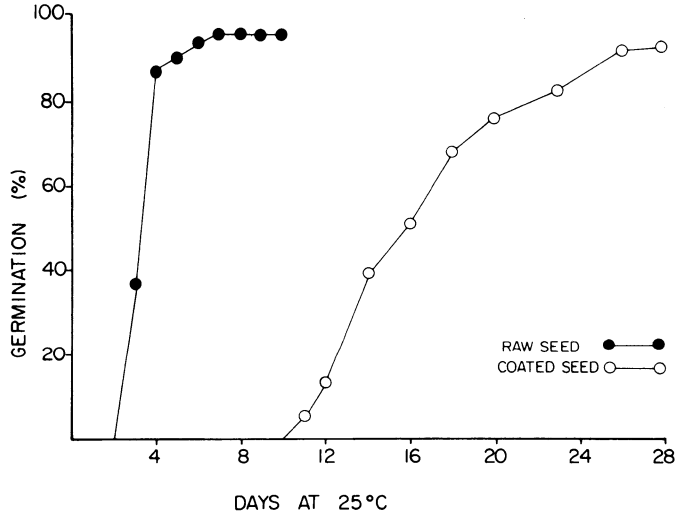

Fig. 1. Germination of raw and clay-coated 'Early Calwonder' pepper seed at 25°C.

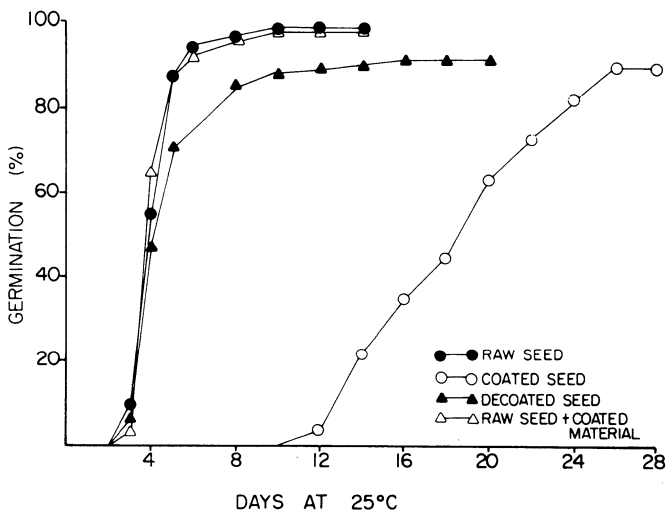

Fig. 2. Germination of raw, coated, decoated, and raw seed in the presence of coating material ('Early Calwonder' pepper).

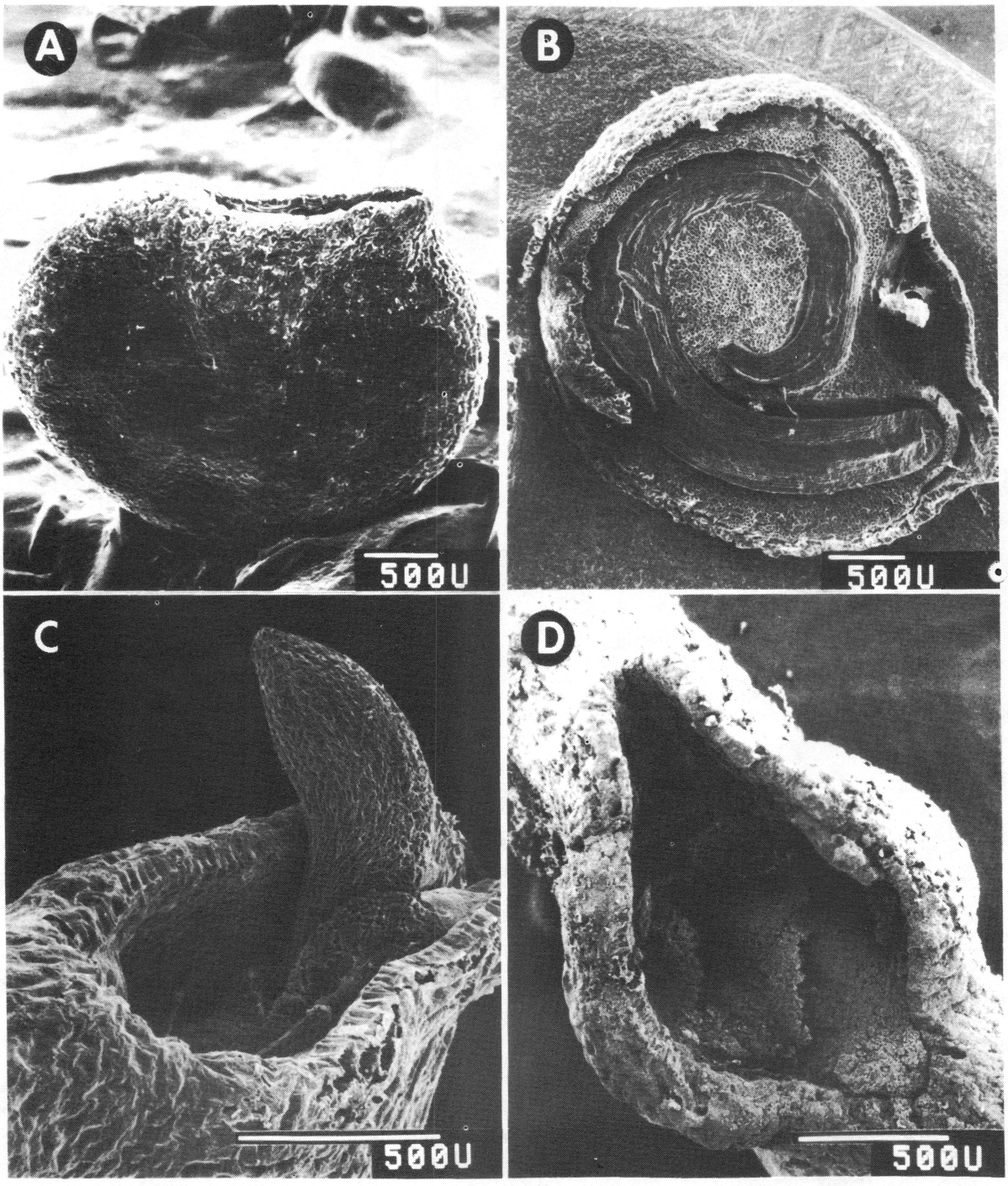

Fig. 3. Scanning electreon micrographs of 'Early Calwonder' pepper seed. A) Whole raw seed. B) Half seed. C) Germinating seed (25°C, 4 days). D) Decoated seed.

The findings that coated seed imbibed in air will start to germinate only 2 days after transfer to high O_2 (Fig.5), that short exposure (up to 12 hr) to high O_2 would not hasten germination in air, and that only 3 days (the time it takes for raw seed to start germination in air) of continuous exposure to high O_2 would result in full germination of coated pepper seed (Fig. 6) pointed to the possibility that high O_2 is needed to maintain the overall high level of metabolism in the germinating coated seed— from the start of the imbibition to radicle elongation.

It was concluded that the inhibitory effect of clay-coating of pepper seed was caused by the physical properties of the coating materials which limited O_2 availability to the seed. The fact that coated sweet pepper seeds are inhibited more than other vegetable seeds may imply differences in O_2 affinity among various species during the germination processes.

Two new coating formulations designed to provide greater O_2 permeability were tested to determine their effect on the germination behavior of sweet pepper seed. Seed coated with "Moran-

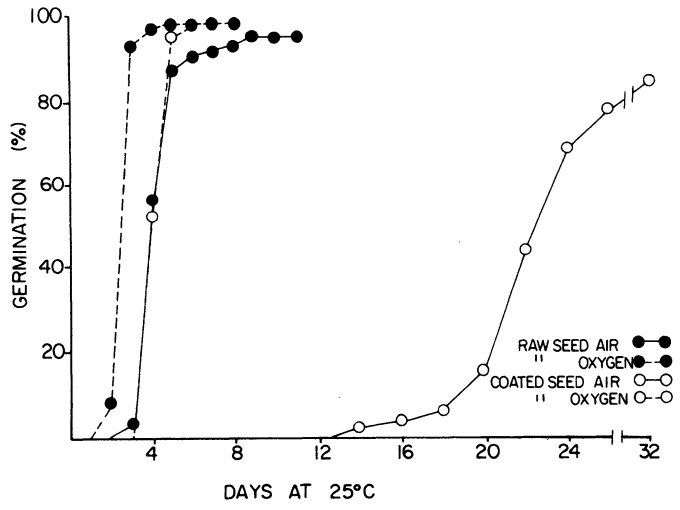

Fig. 4. Germination of raw and clay-coated 'Early Calwonder' pepper seed in high O_2 environment.

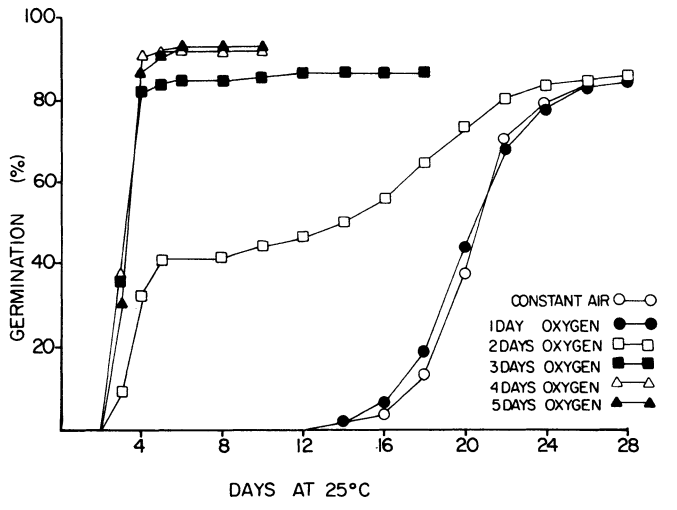

Fig. 6. Germination of clay-coated 'Early Calwonder' pepper seed imbibed for various durations in high O_2 and then transferred to air.

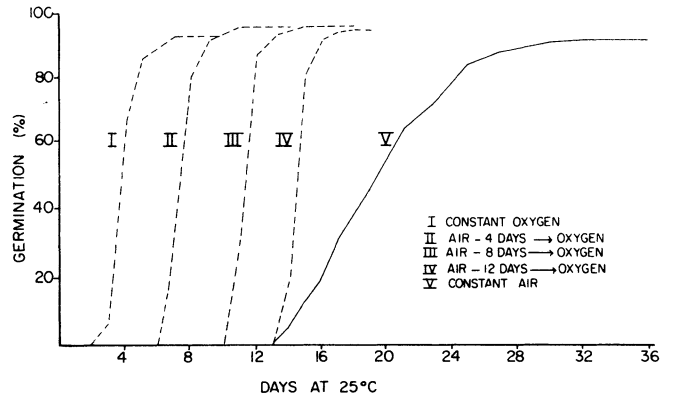

Fig. 5. The effect of high O_2 on germination clay-coated 'Early Calwonder' seed after imbibition for various periods of time in air.

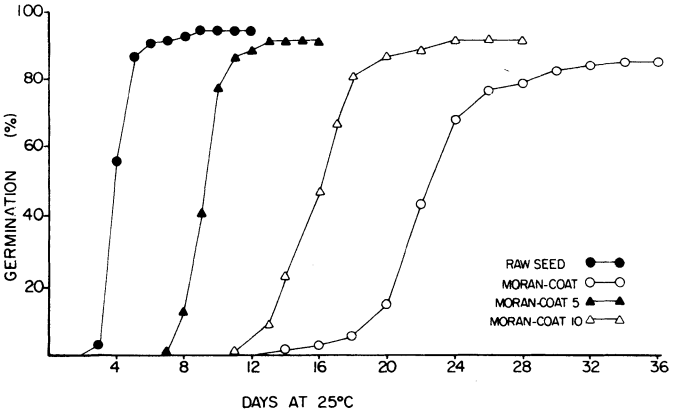

Fig. 7. Germination of 'Early Calwonder' pepper seed coated with different "Moran-Coat" formulations.

Coat 5" and "Moran-Coat 10" formulation resulted in a considerable improvement in germination when compared to a standard "Moran-Coat" formulation (Fig. 7). Both the start of the germination (8.2, 13.8, and 19.8 days respectively) and germination rate (34, 15, and 12% per day, respectively) were increased. However, all seed coatings still delayed the start of germination when compared to raw seed.

Decreased emergence of clay-coated carrot, lettuce, onion, tomato, and sugar-beet seeds and sand-coated lettuce seed was reported to be greatest when soil moisture content was high (7, 8, 9). It was also found that the coating material, in some manner, removed O_2 from water as it passed through the coat toward the seed (12). Thus, if a balanced air to water ratio was created during germination, inhibition of germination from the clay coating might be eliminated. Such conditions can be met by germinating coated seeds on solidified agar. When clay-coated pepper seed was germinated on 0.8% agar, seeds coated with various coating formulations ("Moran-Coat," "Moran-Coat 5", and "Moran-Coat 10") had similar germination patterns (Fig. 8). Germination on agar was more rapid with these coating formulations than germination on filter paper (Fig. 7). Since coated seed, placed on agar, did not germinate as fast as raw seed it indicated that an optimum moisture/air balance was not yet achieved in the coating clay material.

In further experiments, it was established that exposure to high O_2 overcame the effect of clay-coating in delaying (by about 24 hr) germination of 'Ithaca' lettuce (20°C, light) and 'Flora-Dade' tomato (25°, dark) seed. Yet, the same treatment did not enhance the germination of clay-coated '2-14' celery (20°, light) and '2356' tobacco (20°, light) seed (Sachs, unpublished data). Thus it can be generalized that coated seed of species which react differently to high O_2 treatment reflect the different responses of the various seeds to the restricted O_2 flow through clay-coating.

The use of coating formulations which allow a better O_2 supply the the seed, such as "Moran-Coat 5" or "Splitkote" (a coating formulation made by Royal Sluis, Inc., Salinas, Calif.) (Sachs, unplished data) indicates that clay-coating of sweet pepper seed is possible without the adverse effects of reduced rate and lower final percentage of germination.

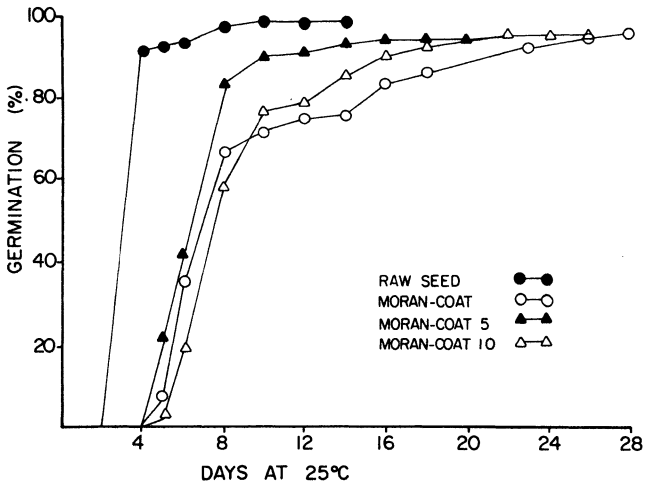

Fig. 8. Germination of clay-coated 'Early Calwonder' pepper seed on 0.8% agar.

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J. Amer. Soc. Hort. Sci. 106(3):389–393. 1981.

The Influence of Summer Pruning on Photosynthesis, Transpiration, Leaf Abscission, and Dry Weight Accumulation of Young Apple Trees[1]

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Additional index words. Malus domestica

Abstract. **Young, container-grown 'Topred Delicious'/Malling (M) 9 apple trees (*Malus domestica* Borkh.) trained to a single shoot out-of-doors were summer pruned to remove 0, 25, 50 or 75% of 78 cm shoots. Net photosynthesis (Pn) and transpiration (Tr) were as much as 36% greater on older, basal leaves of trees with 50 and 75% shoot removal than on unpruned trees. These differences were present for 39 days after pruning. Basal leaves did not abscise in the 11-week period after pruning on trees with 75% shoot removal and remained longer on trees with 50% shoot removal than on unpruned trees. Leaf area removed by pruning was partially compensated by leaves on subsequent regrowth. All summer pruning treatments suppressed the area of individual leaves on regrowth by about 50% of the size of similar aged leaves on unpruned trees. Summer pruning suppressed the dry weight of basal stem sections and roots roughly in proportion to shoot removal amounts, while dry weight of shoot regrowth was less influenced. Eleven weeks after pruning, dry weight of roots on summer pruned trees with 25, 50 and 75% shoot removal was 20, 39 and 50% less, respectively, than root dry weight of unpruned trees.**

Although summer pruning is now being used in some high-density apple orchards in an attempt to control tree vigor and improve fruiting, there are conflicting reports of the effects of summer pruning on apple trees. Summer pruning caused less subsequent shoot growth on young apple trees than dormant pruning (1, 6), but there was no difference between dormant and summer pruning on subsequent shoot growth of older, bearing trees (11, 19). Aselage et al. (2) found that early summer pruning caused more regrowth on early cultivars than on late cultivars. Elfving (8) reported that early summer pruning of 'Delicious' trees resulted in 20% more total extension growth than on unpruned trees; while pruning in early July or August caused less total extension shoot growth. Maggs (14) found that early pruning resulted in at least twice as much regrowth as later summer pruning and the increased invigoration was still apparent the following season.

[1]Received for publication May 14, 1980. Approved for publication as Journal Article No. 88–80 of the Ohio Agricultural Research and Development Center, Wooster.

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