

ALBINISM AND ABNORMAL DEVELOPMENT OF AVOCADO SEEDLINGS¹

J. M. Wallace and R. J. Drake

J. M. Wallace is Pathologist and R. J. Drake is Principle Laboratory Technician, both at the University of California Citrus Experiment Station, Riverside, California.

INTRODUCTION

In 1917, Hodgson^{2/} described an abnormal albino-type avocado plant which he discovered among seedlings being grown for experimental use, and suggested that the condition may have arisen from a bud mutation. Horne^{3/} mentioned and illustrated such plants and stated that the modified, albino-type leaves were composed of tissues similar to those of the white leaf scales which normally appear at the base of the stem of young avocado seedlings.

In 1952, Haas^{4/} reported on some studies in which he obtained a high percentage of abnormal avocado seedlings grown from a lot of seeds taken from a parent tree infected with the virus that causes the disease known as avocado "sun-blotch". Inasmuch as another lot of seeds from a tree believed not to be infected with this virus, yielded no off-type seedlings, Haas concluded that seed-transmitted virus was responsible for the disordered development. No transmission tests were made to demonstrate if sun-blotch virus was present at any time in the abnormal plants. All affected seedlings were reported to have recovered by the gradual production of normal appearing tissues and the symptoms suspected of being sun-blotch did not reappear.

Because of their interest in the matter of seed transmission of the avocado sun-blotch virus, the writers— were conducting studies on albino avocado seedlings at the time Haas reported the results of his observations. Since preliminary experiments of the writers had indicated that the virus was not causally related to the abnormal avocado seedlings, these studies were expanded in an attempt to determine the cause of the seedling abnormalities.



Main entrance to Administration Building, Citrus Experiment Station, Riverside, Calif.



North Wing of Administration Building at the Citrus Experiment Station, Riverside, Calif.

DESCRIPTION OF ABNORMAL SEEDLINGS

In these studies, the off-type seedlings exhibited a wide range in degree of albinism and abnormal growth. *Figure 1.*

(Insert *Fig. 1*)

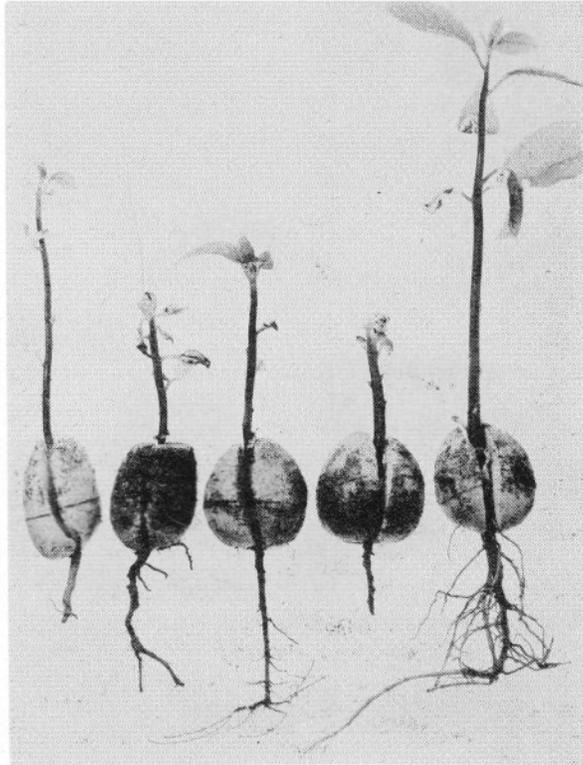
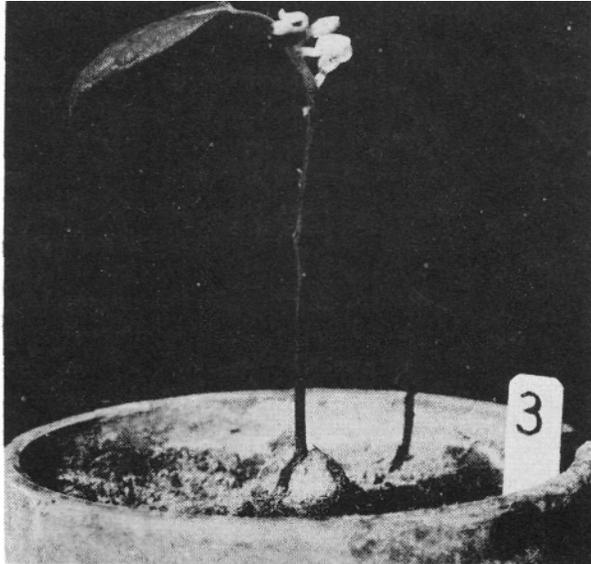


Fig. 1. Types of abnormalities and degrees of albinism in avocado seedlings.

In some instances, the terminal consisted of modified fleshy, whitish leaves which developed after a period of more normal stem elongation. *Figure 2.*



(Insert Fig. 2)

Fig. 2. Albinism and abnormal terminal development on avocado seedling which had shown only slightly albino leaves in earlier stages of growth.

If such plants survived, they made no additional terminal growth, but normal appearing shoots developed from buds below. *Figure 3.*

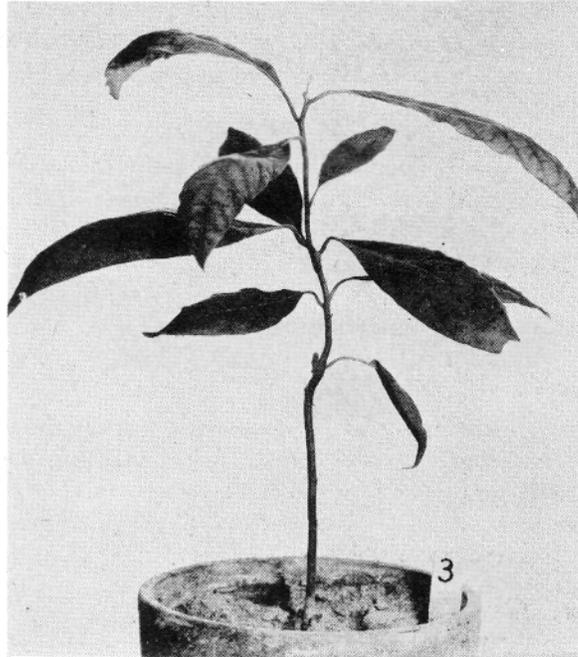


Fig. 3. Same plant as shown in Fig. 2 five months later. Recovery took place from an axillary bud immediately above the two aborted shoots shown in Fig. 2. Opposite the lowest leaf can be seen a dried stub of one of the albino shoots.

Such shoots arose from buds immediately below the terminal knob or from points at the basal part of the stem. On such severely affected seedlings root growth was poor and sometimes the plants succumbed before new shoots developed.

Less severely affected seedlings displayed varying degrees of albinism and malformation. Stem elongation was not retarded, but the first formed leaves were fleshy and colorless. Later, developing leaves progressively became less albino and were often normal in color and size by the time the seedlings had attained a height of twelve inches. After recovery, no plants were observed to revert to the albino condition.

Seed transmission of the virus causing avocado sun-blotch: Prior to the studies of Wallace and Drake⁵, it was believed that the sun-blotch virus was transmitted through seeds only rarely. On occasions, true cases of the disease were found on young seedlings and because there are no known means of infecting avocado plants with this virus except by tissue grafting, it was accepted that these represented instance of passage of the virus through seeds. The more recent studies have demonstrated that high percentages of the seedlings grown from at least certain infected parent trees are carriers of the virus. Such seedlings also remain symptomless, but virus can be transmitted from them. So far, in instances where this phenomenon has been demonstrated, the parent trees likewise have been symptomless carriers.

Inasmuch as the sun-blotch virus is sometimes transmitted through nearly all seeds

from a particular source, any albino seedlings, which might arise in such a group of seedlings, could also by chance be carriers of the virus. However, in order to conclude that the virus was responsible for the albino condition, it would be necessary to demonstrate the presence of virus in all albino seedlings.

EXPERIMENTAL RESULTS

Preliminary germination test of seeds from healthy trees and from sun-blotch-infected sources gave results indicating that the seedling abnormalities were not caused by virus infection. During the course of these investigations, it was suggested by E. Frolich, University of California at Los Angeles, that the abnormalities were found most commonly in seeds from avocado fruits harvested before maturity. With this factor in mind, later experiments combined studies of both virus and immaturity of seeds.

Albinism in seedlings grown from seeds from sun-blotch-infected sources.

Experiment 1: In 1952, mature fruit was harvested from 4 young avocado trees which earlier had been experimentally infected with the virus of sun-blotch and were just beginning to bear fruit. The seedling trees had strong symptoms of the disease. Many of the fruits were marked with the characteristic depressed streaks found on some of the fruits of diseased trees. A total of 39 seedlings developed from this planting and all of them grew normally and without any signs of albinism.

Experiment 2: In a second test on seeds from sun-blotch-infected sources, an attempt was made to compare immature and mature seeds. Seven young trees supplied small numbers of seeds for this test. These were seedling trees of named Mexican seedling varieties. The original parent selections of all of these are reported to have a ripening period beginning in October, according to the description published by the California Avocado Society.

Samples of fruit were harvested from these trees, beginning August 13 and ending October 23. The seeds from fruits showing sun-blotch symptoms were germinated separately from the seeds of normal appearing fruits. The results are summarized in Table 1. These data show that some seedlings, grown from diseased parent sources, are of the abnormal type, but that the majority develop normally. The presence of symptoms on the fruit from which seeds were taken had no influence on the production of albino seedlings. A further point indicated is that if albinos result from immature seeds, the seeds tested in this instance had become quite mature one and a half months before the normal fruit ripening season. The high percentage of germination in the early collections also suggested advanced seed maturity. Another test was then made over a longer period of fruit development in order to include seeds in earlier stages of maturity.

Table 1. Albinism in seedlings from sun-blotch-infected trees.

(Normal Fruit Season October-November)

Variety & Tree No.	Fruit Symptoms	Date		Number		
		Fruit Picked	Seeds Planted	Seeds Planted	Seeds Germinated	Albino Seedlings
Ganter 1	-	Aug. 13	Aug. 24	3	3	0
	-	Oct. 16	Oct. 26	7	7	0
Northrop 1	-	Aug. 13	Aug. 24	15	15	2
	-	Sept. 28	Oct. 6	26	26	3
Harman 1	-	Aug. 13	Aug. 24	2	2	0
	-	Oct. 16	Oct. 21	4	4	0
Harman 2	-	Aug. 13	Aug. 24	4	4	0
	-	Oct. 16	Oct. 22	5	5	0
Harman 3	-	Sept. 28	Oct. 6	26	21	3
	-	Oct. 15	Oct. 26	30	29	1
Harman 4	+	Aug. 13	Aug. 24	4	4	0
	-	Aug. 13	Aug. 24	5	5	0
	+	Oct. 23	Oct. 29	10	8	0
	-	Oct. 23	Oct. 29	6	4	0
Harman 5	+	Oct. 13	Aug. 24	5	5	0
	+	Oct. 16	Oct. 21	5	4	0

Experiment 3: Six sun-blotch-infected trees of the Hass variety were found with sufficient fruit to permit sampling on 4 different dates. The Hass avocado is a summer ripening variety, with fruit maturity beginning in April. Samples were taken in October, December, February and May, all fruit coming from the same season's crop. The results of germination tests of these samples are given in Table 2.

Table 2. Seed maturity and virus infection in relation to the production of albino avocado seedlings. (Composite samples from 6 diseased trees of Haas variety, summer-ripening.)

Sample No.	Date		Fruit With Symptoms	Number of		
	Fruit Picked	Seeds Planted		Seeds Planted	Seeds Germinated	Albino Seedlings
1	Oct. 2	Oct. 13	-	20	3	3
	Oct. 2	Oct. 13	+	36	12	4
2	Dec. 3	Dec. 14	-	33	31	10
	Dec. 3	Dec. 14	+	43	37	19
3	Feb. 2	Feb. 16	-	16	16	0
	Feb. 2	Feb. 16	+	29	28	0
4	May 3	May 17	-	18	17	0
	May 3	May 17	+	29	23	0

On the basis of the percentage of germination, it appeared that seeds of the Haas variety had become quite well matured by December, even though the fruit did not

reach an edible maturity until April or later. On the other hand, if the occurrence of albino seedlings is used as a criterion of seed maturity, it will be noted from Table 3 that it was only in the seeds harvested in February or later that no albino seedlings developed. At any rate, these data clearly indicate that, in the case of the Hass variety, albinism is associated with seed immaturity. It can be concluded from these tests that the presence of symptoms on the fruits from which seeds originate does not increase the amount of albinism. The absence of albino seedlings in samples 3 and 4 demonstrates that normal seedlings are obtained from seeds of sun-blotch-infected trees, provided other conditions are suitable for normalcy.

Tests for virus in albino seedlings.

Because the possibility still remained that the abnormal seedlings resulted from seed transmission of virus, which could take place more commonly in immature seeds than in those more mature, studies were made of numerous albino seedlings to determine if they were carriers of the sun-blotch virus. Twenty off-type seedlings were indexed to healthy avocado seedlings and healthy scions were topworked onto each of the 20 albino seedlings for demonstrating seed transmission as described by Wallace and Drake⁵. After 2 years, all tests for virus were negative and the conclusion was thus made that there was no virus in the albino seedlings tested.

Albinism and immaturity of seeds from sun-blotch-free sources. After obtaining evidence that the production of albino seedlings was not correlated with seed transmission of the sun-blotch virus, additional studies were made of the occurrence of albinism in seedlings grown from seeds of healthy or virus free trees. Seeds were collected from 20 different avocado trees at various times during the period of fruit development. Germination tests were made and the numbers of abnormal seedlings were recorded. For the purpose of tabulating the data, each sample of seeds was arbitrarily classified as either immature or mature, seeds collected within one and one-half months of the beginning of the normal fruit-picking season being classed as mature* These data are summarized in Table 3.

Table 3. Albino seedlings from immature and mature seeds from virus-free avocado trees.

Seed Source	Immature Seeds			Mature Seeds		
	No. of Seeds	No. Germ.	No. Albino	No. of Seeds	No. Germ.	No. Albino
Duke	51	45	2	60	58	1
Zutano	174	161	4	84	83	0
Geghee	32	24	3	20	17	0
Hass 1	40	28	6	40	28	2
Hass 2	76	64	10	108	74	0
Hass 3	76	44	23	75	71	0
Hass 4	118	86	6	107	78	3
Wright	----	----	----	62	57	0
Coit	26	17	12	7	7	0
Elsie 1	40	23	5	37	18	0
Elsie 2	32	29	10	32	32	0
Fuerte (5 trees)	170	117	27	169	165	5
MacArthur	----	----	----	20	20	0
Edranol	21	15	5	----	----	----
Regina	----	----	----	104	88	0
Ryan	53	35	15	60	48	0
Totals	909	688	128	985	844	11
Percent		69.4	20.4		85.7	1.3

T 3.87 - Differences in albinism between mature and immature seeds highly significant.

It will be noted that, in the immature group, 20.4 percent of the germinating seeds produced albino, or off-type seedlings, while only 1.3 percent of the seedlings from seeds in the mature group were abnormal. As the percentage germination increased, there was usually less albinism in the seedlings, but this was not always true. However, it was not possible to determine if the low germination in some of the lots of late picked fruit resulted from the presence of immature seeds or from other factors unfavorable for seed germination.

The data in Table 3 also indicate that varieties or individual trees of a variety vary to some degree in respect to the ratios of abnormal to normal seedlings. Variations in flowering and fruit-setting periods are probably sufficient to account for the observed differences between seed sources. Even in the collections considered to be from fruit which is mature or approaching maturity, there are, no doubt, some late set fruit which rightfully would fall in the immature class, if they could be identified.

SUMMARY AND CONCLUSIONS

From these studies, it is concluded that the abnormal, albino-type avocado seedlings do not result from infection with the virus of the avocado sun-blotch disease. None of these abnormal seedlings showed any of the characteristic symptoms of sun-blotch either before or after recovery from the albino condition. In transmission tests of twenty albino plants, no virus was obtained.

The abnormal seedlings described in this paper appear most commonly when avocado

seeds are collected prior to a certain stage of fruit maturity. Some of the off-type seedlings, which develop in samples of seeds collected after the normal fruit-ripening period has been reached, may actually originate from off-bloom or late-set fruit. On occasions, however, albino plants have developed from seeds taken from well-matured fruits. The conditioning factors for albinism appear to be retained by some seeds after they have become fully mature.



Close-up of glass chamber used in study of smog effects on plant life, at Citrus Experiment Station, Riverside, Calif.

¹/Paper No. 895, University of California Citrus Experiment Station, Riverside, California.

²/Hodgson, R. W. 1917. An avocado monstrosity. Jour. Heredity 8: 557-558.

³/Home, W. T. 1934. Avocado diseases in California. Calif. Agr. Exp. Sta. Bul. 585.

⁴/Haas, A.R.C. 1952. Sun-blotch in avocado seedlings. Calif. Avocado Society yearbook 1952: 167-171.

⁵/Wallace, J.M. and R. J. Drake. 1953. Seed transmission of the avocado sun-blotch virus. Citrus Leaves 33: 18-20.