California Avocado Society 1951 Yearbook 35: 139-152

VARIATIONS IN THE COMPOSITION OF AVOCADO SEED

R. C. Haas
Plant Physiologist, University of California, Citrus Experiment Station, Riverside.

SUMMARY

Avocado seed are usually considered as waste or as a source of seedlings suitable for use as rootstocks. This paper emphasizes the changing composition of avocado seed and how as a storage organ certain constituents are translocated from it to other portions of the fruit or tree.

The fresh and dry weight and some of the inorganic constituents were determined in the dry matter of the seed of fruits of a number of Mexican and Guatemalan varieties. When the inorganic elements were calculated in terms of grams per seed, the calcium, magnesium, and potassium content of the seed of the Mexican varieties average much less than those of the Guatemalan varieties examined.

Avocado seed contain relatively low amounts of calcium and magnesium, somewhat higher amounts of phosphorus, and high amounts of potassium.

Determinations were made of the fresh and dry weights and inorganic composition of seed of fruit collected at the same time from similar scion varieties grown on different rootstocks under the same orchard conditions.

Calcium in the dry matter of the Fuerte avocado seed from fruit of trees on Topa Topa rootstock was greater than in that of seed from fruit of trees on Mexicola rootstock.

A study was made of seasonal changes in the weights and composition of Fuerte avocado seeds from fruits of a tree on Mexicola as the rootstock variety.

During the early stages of fruit maturity the fresh weight of the seed increases until about the middle of December and then decreases until about February 20. Variations in the grams of water per seed and in the dry weight per seed roughly follow (when plotted) the same trend as that of the fresh weight.

Approximately half of the maximum content of potassium in the seed is translocated or removed from the seed during the period of fruit maturation. Although the calcium and magnesium contents of the seed are relatively low, their content is also greatly decreased as the fruit matures. Such losses from the seed may have some bearing on the time of securing seed for rootstock purposes.

In previous reports (1,2) it was pointed out that the content of inorganic elements in the pulp, skin, and seed of avocado fruit parallels the results found for those elements in the leaf petioles and blades (3). Furthermore the high and low potassium values in the pulp of Fuerte avocado fruit obtained from various orchards were associated with the corresponding high and low potassium values in the skin and seed of these same fruits.

In most avocado analyses the moisture content, seed weight, oil percentage, nitrogen, and ash content are given although constituents of the ash rarely are determined. In the present study the seed alone and without seed coats, constituted the material taken for analysis. In data involving the seed, little interest is usually shown except as to its shape and size and whether its seedling would constitute a desirable rootstock. In most cases the seed is considered as waste. The present paper deals with avocado seed largely from the standpoint of a storage organ and the service it renders the tree at certain stages of fruit maturation.

Moisture, dry matter and inorganic composition of the seed of several Mexican and Guatemalan varieties were first studied. All of the seed of the Mexican varieties were obtained at the Citrus Experiment Station[1] except for the Mexicola variety which was secured from other trees in Riverside and the ten seed of the Puebla variety that were obtained from the Calavo Packing House. The Benik, Hass, and Spinks varieties of seed were obtained at the Citrus Experiment Station whereas the Dickinson, MacArthur, and Queen varieties (the pulp of the last two varieties having 14 and 15 percent oil respectively) were obtained from the Calavo Packing House. The first two samples of seed of the Fuerte variety were obtained at the Citrus Experiment Station whereas the last sample was supplied (from fruit containing 8 percent oil) by the Calavo Packing House.

The analytical determinations were made in duplicate on the dry matter of the seed that had been ground in a Wiley Mill and subsequently redried in heavy paper envelopes at a constant temperature of 65°C.: calcium obtained by the double precipitation as the oxalate, was titrated with potassium permanganate ; magnesium obtained from the combined calcium filtrates was weighed as the pyrophosphate; potassium was determined as the chloroplatinate; and sodium was obtained by difference between the combined potassium and sodium chlorides and the potassium chloroplatinate calculated as the chloride.

Constituents in the seed of Mexican and Guatemalan varieties

In table 1 the inorganic constituents are given in terms of parts per million (p.p.m) in the dry matter and the values can be converted to per cent or parts per hundred by pointing off four places from the right. In addition and of more importance are the calculations for the several inorganic constituents in terms of grams per seed. It is possible for the dry matter of a seed to have a low content (p.p.m.) of an element in the dry matter but, by virtue of the seed size, the seed might contain a high content of that element when it is expressed as grams. For the varieties used in table I, the seed of the Mexican varieties averaged smaller in fresh and dry weights and in the per cent of dry matter in the fresh weight. Note the relatively low concentration of calcium, magnesium, and sodium and the extremely high content of potassium in the dry matter of the seed. In addition note that the magnesium content in the dry matter, with few exceptions, was greater than that of calcium. The potassium content in the dry matter is roughly 20 to 25 times greater than that of calcium and about 15 to 20 times greater than that of magnesium. The calcium and magnesium content in the dry matter averaged slightly higher in the Guatemalan than in the Mexican varieties of seed although the potassium content was about the same in both groups of seed. In a previous report (2) the total phosphorus content in the dry matter of Fuerte avocado seed was shown to range from 815 to 1980 p.p.m. (dependent on the type of fertilizer used) and was from one to two times as great as the content of magnesium.

When the inorganic constituents are calculated in terms of grams per seed, the calcium, magnesium, and potassium content of the seed of the Mexican varieties averaged much less than those of the Guatemalan varieties.

Scions and rootstocks

Fruit from similar Fuerte scions on various rootstocks were collected on January 31, 1951 in the Citrus Experiment Station avocado orchard and on February 9, 1951 the fruit were soft to the touch, at which time the seed were removed. After discarding the seed coats, the seed were scrubbed in running distilled water and when wiped dry the fresh weights of the samples of seed were obtained. The seed were then cut to facilitate the drying process conducted in a ventilated oven maintained at 65° C. When constant weight was reached, the dry weights were obtained and the seed were ground and dried as in previous seed samples.

The fruits, other than Fuerte, were collected on February 5, 1951 (Hellen on Mexicola was collected January 31, 1951) in the Citrus Experiment Station orchard and the seed were removed during the period February 14 to 20, 1951 as the fruit became soft to the touch.

All the Fuerte avocado trees sampled (table II) are located in row 20; Regina variety is located in row 8, Hellen in row 17, and Irving in row 18.

For the seed tested, the fresh and dry weights of the seed of the Carr and Anthony Fuerte varieties respectively on Topa Topa rootstock were less than when on Mexicola rootstock. Hellen variety seed also showed this same relationship to the rootstock. The seed of the Cole Fuerte fruit had the largest fresh and dry weights. Carr Fuerte seed contained a greater percentage of dry matter in their fresh weight than the Cole or Anthony Fuerte seed.

Calcium in the dry matter of the Fuerte avocado seed from fruit of trees on Topa Topa rootstock was greater than in that of seed from fruit of trees on Mexicola rootstock. Previous results (4) with leaves of trees on these two rootstocks showed that the leaves contained more calcium in their dry matter when from trees on Topa Topa than from trees on Mexicola rootstock. The average content of calcium and magnesium in the dry matter of the seed was least in that of the Cole Fuerte variety whereas magnesium was highest in seed of the Carr Fuerte variety. The average potassium content in the dry matter of Fuerte seed was highest in the Cole Fuerte variety.

When grams per seed are considered, the seed obtained from fruit of trees on Mexicola as rootstock contained more magnesium and potassium than when Topa Topa was the rootstock. For the various Mexican rootstocks, the Carr Fuerte seed contained a higher average magnesium content per seed than the other Fuerte varieties tested.

TABLE I

Fresh and dry weight of avocado seed of various varieties together with the inorganic content in the dry matter and in an average seed.

Variety	No. of seed	Fresh wt. per seed (grams)	Dry matter per seed (grams)	Dry matter in fresh wt. (per cent)	In dry matter (parts per million)				Grams per seed			
					Ca	Mg	K	Na	Ca	Mg	K	Na
MEXICAN												
Blake	16	25.3	10.19	40.3	271	772	12.170	265	.0028	.0079	.1240	.0027
Blake	5	23.2	9.00	38.8	293	822	12.865	160	.0026	.0074	.1158	.0014
Blake	6	23.2	9.83	42.4	340	606	12.270	105	.0033	.0060	.1206	.0010
Caliente	6		21.05		670	1030	13.206	446	.0141	.0217	.2780	.0094
Caliente	13	38.9	25.15	64.8	441	867	13.125	50	.0112	.0218	.3301	.0013
Clifton	12	35.0	15.04	43.0	250	675	15.910	25	.0038	.0102	.2393	.0004
Duke	9	31.3	9.06	28.9	311	614	14.670	310	.0029	.0056	.1329	.0028
Ganter	6	12.0	5.25	43.9	581	616	11.710	40	.0031	.0033	.0615	.0002
Harman	8	36.2	14.00	38.7	1030	727	13.241	380	.0144	.0102	.1854	.0053
Harman	6	48.7	19.40	39.9	636	782	13.265	40	.0123	.0151	.2573	.0008
Mexicola	8		10.84		363	588	13.233	308	.0039	.0064	.1434	.0033
Northrop	9	15.7	7.28	46.4	584	780	15.400	120	.0043	.0057	.1121	.0009
Northrop	22	18.7	6.85	36.6	585	650	13.500	50	.0040	.0045	.0925	.0003
Puebla	5	23.5	6.80	28.9	811	530	12.660	135	.0055	.0036	.0861	.0009
Puebla	6	39.6	16.72	42.2	561	672	13.580	115	.0094	.0112	.2271	.0019
Puebla	10	20.2	9.09	44.9	1330	576	13.285	125	.0121	.0052	.1208	.0011
Puebla	4				311	484	15.895	180				
Puebla	8	27.5			635	518	13.860	15				
Topa Topa	10	18.8	5.97	31.8	899	1047	15.765	185	.0054	.0063	.0941	.0011
Average	9	27.4	11.85	40.8	574	703	13.664	161	.0068	.0089	.1600	.0020
GUATEMALAN												
Anaheim	3		31.67		313	1216	14.980	610	.0099	.0385	.4744	.0193
Benik	8	36.6			527	698	14.590	20				
Carlsbad	3		14.10		317	744	18.704	269	.0045	.0119	.2637	.0038
Dickinson	15	32.4	14.55	44.9	889	1377	11.070	175	.0130	.0201	.1611	.0026
Hass	4		13.25		547	1233	12.306	494	.0072	.0163	.1631	.0065
MacArthur	6	47.3	27.50	58.1	768	708	11.100	60	.0212	.0195	.3053	.0017
Nabal	3		36.77		382	899	14.194	551	.0140	.0331	.5219	.0203
Queen	8	37.5	21.41	57.1	1402	1138	12.985	50	.0301	.0244	.2780	.0011
Spinks	3		31.10		441	752	11.887	381	.0137	.0234	.3697	.0118
Average	6	38.5	23.79	53.4	621	985	13.535	290	.0142	.0234	.3172	.0084
MEXICAN X GUATEMALAN												
Fuerte	8				392	990	14.480	50				
Fuerte	6				388	1108	13.495	130				
Fuerte	10	31.2	12.48	40.5	413	691	14.535	440	.0052	.0086	.1814	.0055
Average	8				398	930	14.170	207				

TABLE II

Inorganic composition of the seed from fruit of similar avocado scions on various Mexican rootstocks.

Scion and rootstock	Tree No.	No. of seed	Fresh wt. per seed (grams)	Dry wt. per seed (grams)	Dry matter in fresh wt. (per cent)	In dry matter (parts per million)				Grams per seed			
						Ca	Mg	K	Na	Ca	Mg	K	Na
Carr Fuerte on Mexicola	3	8	48.90	19.98	40.85	393	947	15,592	341	.0079	.0189	.3115	.0068
Carr Fuerte on Ganter	2	7	51.24	21.56	42.07	338	896	15,924	197	.0072	.0194	.3433	.0043
Carr Fuerte on Topa Topa	1	6	45.02	19.03	42.28	459	862	14,517	118	.0088	.0165	.2763	.0023
Average		7	48.39	20.19	41.73	397	902	15,344	219	.0080	.0183	.3104	.0045
Cole Fuerte on Mexicola	6	4	54.45	20.38	37.42	323	666	16,501	499	.0065	.0136	.3363	.0102
Cole Fuerte on Harman	4	2	51.90	20.50	39.50	318	782	16,615	164	.0065	.0160	.3406	.0034
Cole Fuerte on Ganter	5	6	52.77	21.03	39.86	378	763	15,566	341	.0080	.0160	.3274	.0072
Average		4	53.04	20.64	38.93	340	737	16,227	335	.0070	.0152	.3348	.0069
Anthony Fuerte on Mexicola	12	6	52.68	21.17	40.18	319	801	15,378	439	.0068	.0170	.3256	.0093
Anthony Fuerte on Ganter	13	7	49.77	19.60	39.38	500	730	14,919	269	.0098	.0143	.2924	.0053
Anthony Fuerte on Topa Topa	14	7	45.29	17.51	38.67	364	787	15,662	406	.0064	.0138	.2742	.0071
Average		7	49.25	19.43	39.41	394	773	15,320	371	.0077	.0150	.2974	.0072
Newman Fuerte on Harman	8	7	42.86	16.71	39.00	386	816	15,758	380	.0064	.0136	.2633	.0064
Hellen on Mexicola	3	6	50.30	20.37	40.49	459	1038	14,019	183	.0094	.0212	.2856	.0037
Hellen on Topa Topa	4	6	46.80	19.00	40.60	488	884	13,049	315	.0092	.0168	.2479	.0060
Regina on Mexicola	4	6	33.90	10.23	30.19	250	854	20,452	485	.0025	.0088	.2092	.0050
Regina on Ganter	3	6	29.95	11.78	39.34	273	710	14,202	695	.0032	.0084	.1673	.0082
Irving on Harman	2	1	23.70	9.00	37.97	277	595			.0025	.0054		

The data in table II were obtained from seed of fruit collected at corresponding times from trees grown under comparable conditions of irrigation and fertilization. The data indicate the desirability of a comparison of the seed of fruit of similar scions not only on Mexican but also on Guatemalan rootstocks, but unfortunately such material is not yet available.

An avocado seed contains the embryonic plant but in addition serves as a large storage organ. This storage portion is ever changing as regards its content of moisture, dry matter, or inorganic nutrient elements.

In citrus trees the fruits are subject to withdrawals of water and nutrient elements as the environment changes throughout the day and imposes stresses upon the tree. During the night or at some other intervals compensating accumulations take place and restore the former equilibrium; otherwise injury occurs. In citrus, for example, the magnesium nutrition is related to the seediness and setting of the fruit. In avocado fruit there is only one seed and any serious interference with its moisture, dry matter (organic) or inorganic nutrition may possibly affect the quality of the fruit, or may result in the fruit abscission. Frequently avocado seed are loose within the fruit and rattle upon shaking the fruit. Losses of avocado fruit in serious proportions at various stages of fruit development are often difficult to account for.

It seemed desirable to follow the course of the nutrition process in Fuerte avocado seed from the time the fruit approaches the required oil-content stage and to follow it as far as possible beyond that stage. Tables I and II have shown that the seed has a large content of water and a very small content of some inorganic elements. The data in the tables also may give the impression that the moisture, dry matter, and inorganic content of avocado seed is relatively constant once the fruit becomes edible. Studies with citrus fruit, however, would indicate that there may be a considerable dependence between the physiology of the vegetative and reproductive phases of growth.

Seasonal changes in Fuerte avocado seed

In order to determine whether the contents of avocado seed fluctuate during the maturation of the fruit, a study was made of seed from a single large tree bearing a large crop of readily accessible fruit. The tree was of the Fuerte variety on Mexicola rootstock (R18, Tl) in the orchard at the Citrus Experiment Station. Fruit was collected at various intervals after they had reached the edible stage. The fruit was kept at room temperature until soft to the touch at which time the seed was removed. The seed coats were discarded and the seed was scrubbed in running distilled water and wiped dry; this and the subsequent preparation of the samples being the same as used in previous tests.

Table III gives the compiled data obtained from the weighings of the seed and from the duplicate chemical determinations of the dry matter. The trends, if any, are difficult to follow from a casual inspection of the table, hence the data have been plotted and presented more clearly in graph form.

TABLE III

Seasonal variations in the moisture, dry matter, and inorganic content of Fuerte avocado seed.

Fruit picked	Fruit opened	No. of seed	Fresh wt. per seed (gms.)	Water content per seed (gms.)	Dry wt. per seed (gms.)	Dry matter in fresh wt. (per cent)	In dry matter (parts per million)				Ca (p.p.m.) / Mg (p.p.m.) in dry matter	Grams per seed			
							Ca	Mg	K	Na		Ca	Mg	K	Na
1950	1950														
Nov. 1	Nov. 7	7	40.84	24.71	16.09	39.38	492	961	16,318	380	1.95	.0079	.0155	.2626	.0061
Nov. 16	Nov. 27	7	40.20	24.21	16.00	39.79	469	925	16,055	381	1.97	.0075	.0148	.2569	.0061
Nov. 27	Dec. 6	8	47.71	28.51	19.20	40.24	399	874	16,344	682	2.19	.0081	.0169	.3138	.0131
Dec. 7	Dec. 18	8	48.75	27.84	20.91	42.90	395	962	15,522	263	2.19	.0083	.0201	.3246	.0055
Dec. 18	Dec. 27	7	47.40	28.40	19.00	40.08	346	881	16,825	354	2.55	.0067	.0167	.3197	.0067
1951	1951														
Jan. 5	Jan. 16	8	39.00	24.29	14.75	37.78	408	971	16,964	426	2.38	.0060	.0143	.2502	.0063
Jan. 15	Jan. 26	9	34.67	20.76	13.91	40.13	433	981	16,230	387	2.27	.0061	.0136	.2258	.0054
Jan. 31	Feb. 9	7	34.07	21.48	12.63	37.06	459	996	15,697	537	2.17	.0058	.0126	.1983	.0068
Feb. 9	Feb. 20	7	29.93	18.37	11.56	38.62	599	833	15,243	367	1.39	.0069	.0096	.1762	.0042
Feb. 26	Mar. 6	7*	38.49	23.69	14.80	38.46	342	928	16,877	203	2.71	.0050	.0138	.2498	.0030
Mar. 7	Mar. 15	7	35.53	20.96	14.57	41.01	477	943	15,645	302	1.98	.0069	.0138	.2280	.0044
Mar 16	Mar. 23	7	36.60	22.74	13.86	37.86	410	998	16,623	623	2.43	.0057	.0139	.2304	.0086
Mar. 26	April 3	7	39.66	23.66	16.00	40.35	440	856	14,945	472	1.95	.0070	.0138	.2391	.0076
April 3	April 9	7**			17.76		323	803	15,977	413	2.49	.0058	.0143	.2838	.0073
April 9	April 16	8**	26.84	16.46	10.38	38.66	536	938	15,750	629	1.75	.0055	.0097	.1635	.0065
Average (Entire season)		7	38.55	23.29	15.43	39.45	435	923	16,068	428	2.16	.0066	.0142	.2482	.0065

* Seed sprouting

** Seed extremely variable in size

Figure 1 shows the changes in the fresh weights (grams) per seed during the season extending from November 7, 1950 to April 16, 1951. During the early part of the season the fresh weight of the seed increases until about the middle of December, after which it decreases until about February 20. Following this, there is another increase which terminates in a sharp decrease late in the season.

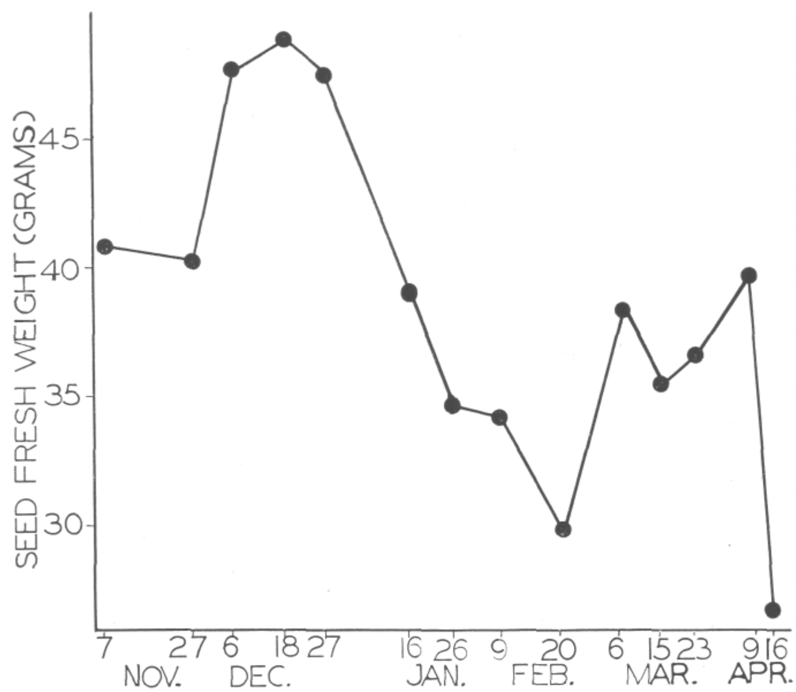

Fig. 1. *Some seasonal variations in the grams of fresh weight per seed of Fuerte avocado fruit.*

The seasonal variations in the grams of water per seed are plotted in figure 2. The curve has the same trend as that for the fresh weights per seed (figure 1). Between February 20 and April 16 in both figures there is a secondary though temporary increase which may possibly be related to the abscission of old leaves and the onset of blossoms and new leaves. The steepness of the decrease after early December as affected by various soil-irrigation practices would form an interesting study at another time.

Again following the trend of figures 1 and 2 is that of the graph for the changes in the dry weight per seed (figure 3). The graphs (figures 1, 2 and 3) indicate that considerable amounts of dry matter and moisture are withdrawn from the seed during the progress of maturation of the fruit. Whether the dry matter and moisture removed from the seed has been translocated for use in the development of the pulp or has been shifted for use by the leaves or for the formation of blossoms is not presently known. Obviously if the sale of avocado fruit were based on weight, and the price remained constant, these changes in the seed as the maturation proceeds would become increasingly advantageous to the consumer.

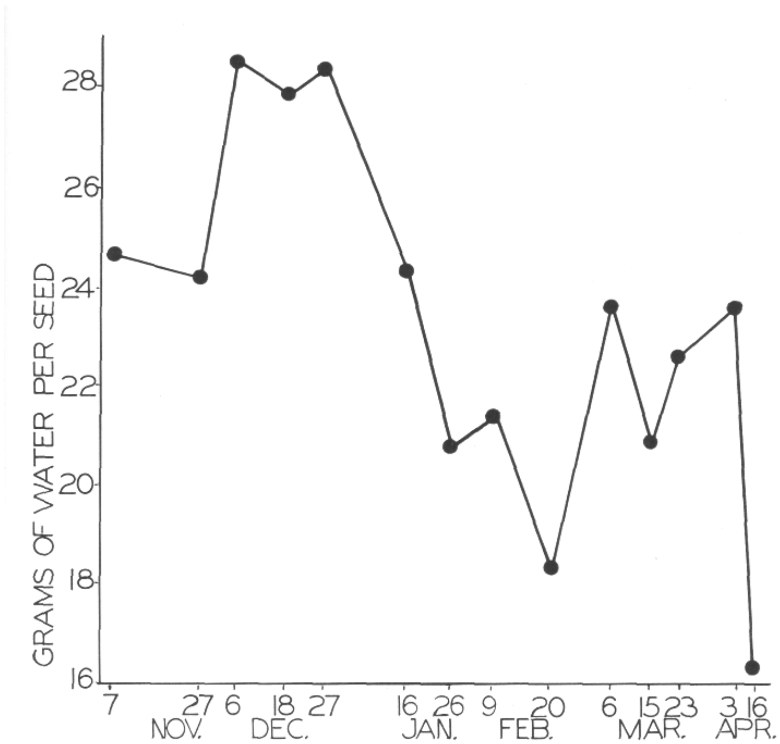

Fig. 2. *Changes in the grams of water per seed during fruit maturation.*

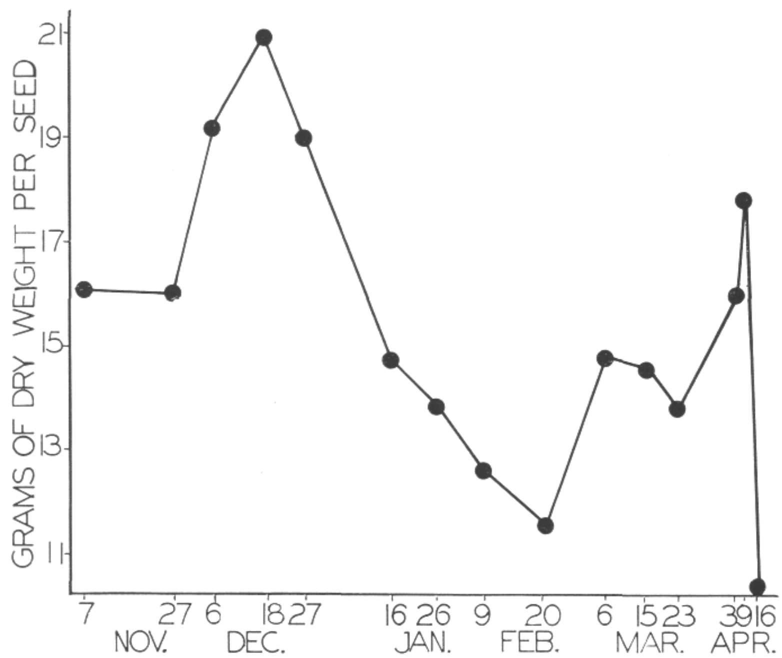

Fig. 3. *Dry weight variations per seed as the season progresses.*

Table III shows the relatively large content of potassium in the dry matter of the seed. If the seasonal variations in the potassium (K) content (p.p.m.) in the dry matter are plotted (figure 4) it is difficult to follow the trend. From January 16 to February 20 the graph shows the most regularity but elsewhere the graph is most irregular largely because the dry matter on which it is based is itself continually changing. It appears therefore that graphs based on "grams per seed" afford a better opportunity to observe seasonal variations within the seed.

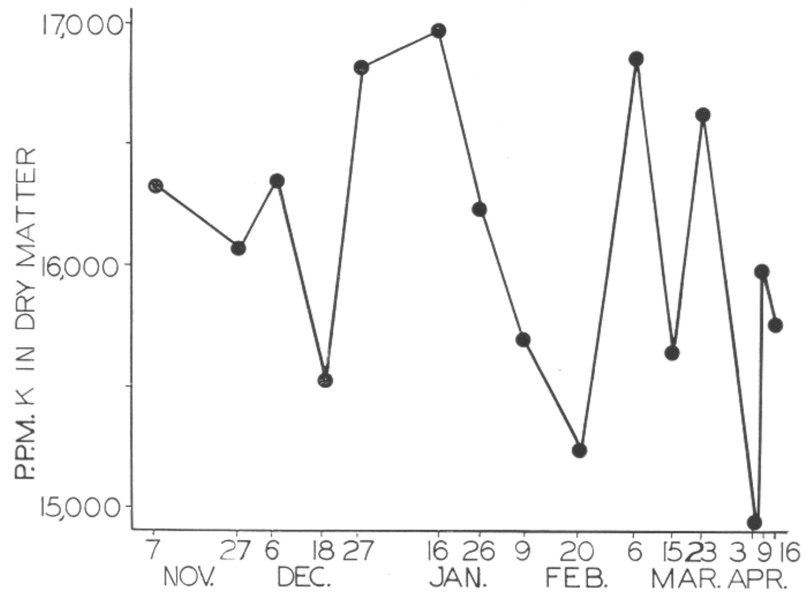

Fig. 4. *Erratic type of curve obtained when changes in the parts per million of potassium (K) in the dry matter of Fuerte avocado seed are plotted for the period of fruit ripening.*

When the data for the potassium (K) content (grams) per seed are plotted, the graph (figure 5) is seen to resemble the previous graphs based on "grams per seed". Approximately half the maximum content of potassium in the seed is translocated from the seed during the course of the season. It raises the question as to whether seed obtained by nurserymen would have greater vitality were they collected during the peak portion of the graphs rather than being obtained later in the season after severe losses to the seed have occurred.

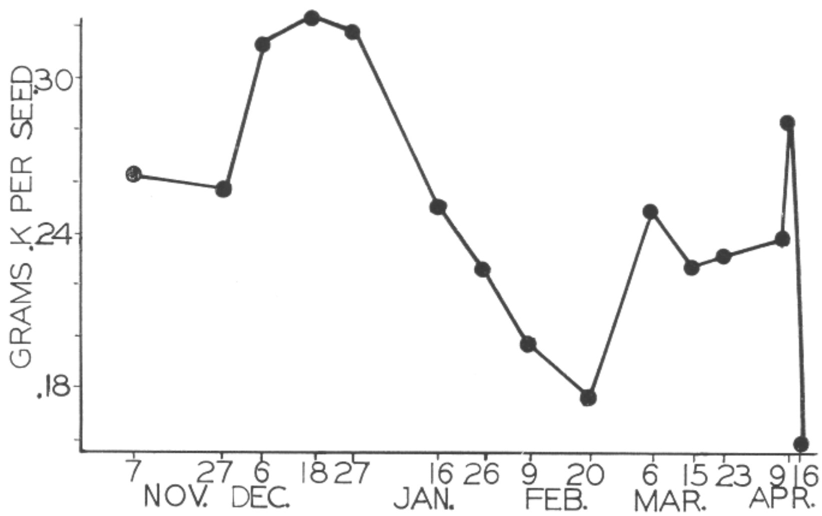

Fig. 5. *Improved type of curve obtained when changes in the grams of potassium (K) per seed are plotted for the period of fruit maturation.*

The content of calcium and magnesium in an avocado seed is relatively small in amount and yet this quantity (grams per seed) varies considerably during the maturation of the fruit. Figure 6 shows the very slight increase followed by an abrupt and then more gradual decrease in the grams of calcium per seed as the season progresses.

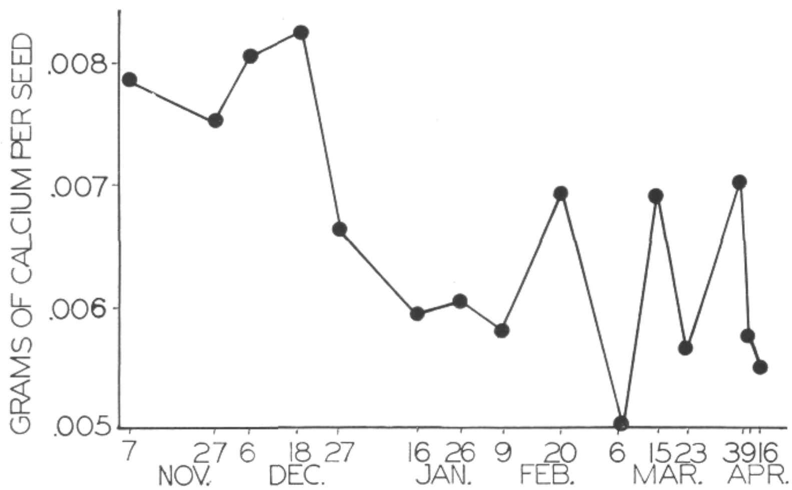

Fig. 6. *Grams of calcium per seed as the season progresses.*

The data for the Fuerte seed (table III) show that magnesium was present in larger amount than calcium in the seed. Early in the season, for about three weeks, the magnesium content per seed (figure 7) increased markedly and then decreased continuously until February 20 after which some recovery occurred before a final decrease. Very late in the season as indicated in table III, some seeds had begun to sprout, while in the fruit in which case the sprouts were included in the sample.

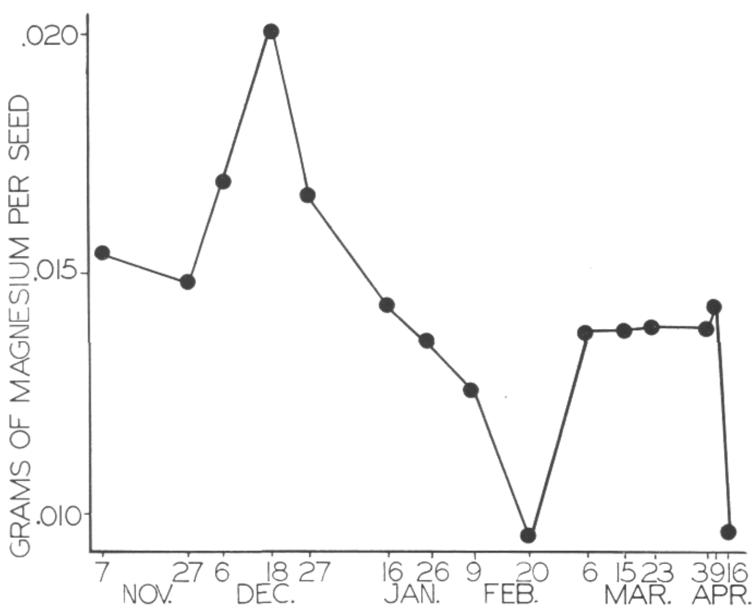

Fig. 7. *Seasonal changes in the content of magnesium per seed.*

Avocado leaves have a relatively high magnesium and low calcium content as compared with those of citrus. The magnesium: calcium ratios in the dry matter of the seed as the season progressed, are shown in table III. When plotted in figure 8, the graph indicates an initial increase in the ratio and a subsequent decline and recovery. If from table III the ratios are calculated for an average seed instead of for the dry matter during the sampling season, the following values are obtained: 1.96, 1.97, 2.10, 2.43, 2.51, 2.40, 2.25, 2.17, 1.38, 2.73, 1.99, 2.44, 1.95, 2.48, and 1.77 respectively. When these values are plotted they give approximately the same graph as shown in figure 8.

The figures as a whole indicate that the near peak portion of the curves was reached about December 18 and the low portion about February 20. The graphs show some of the seasonal changes that occur within a Fuerte avocado seed at Riverside. Further studies will include the pulp and other avocado varieties. The graphs quite clearly indicate that an avocado seed is continually in a state of change, gaining and then losing certain constituents. An avocado seed serves both as a reproductive organ and as a reserve storage organ. By means of seasonal graphs based on "grams per seed" rather than on dry matter, the course of avocado seed nutrition can be quite readily followed.

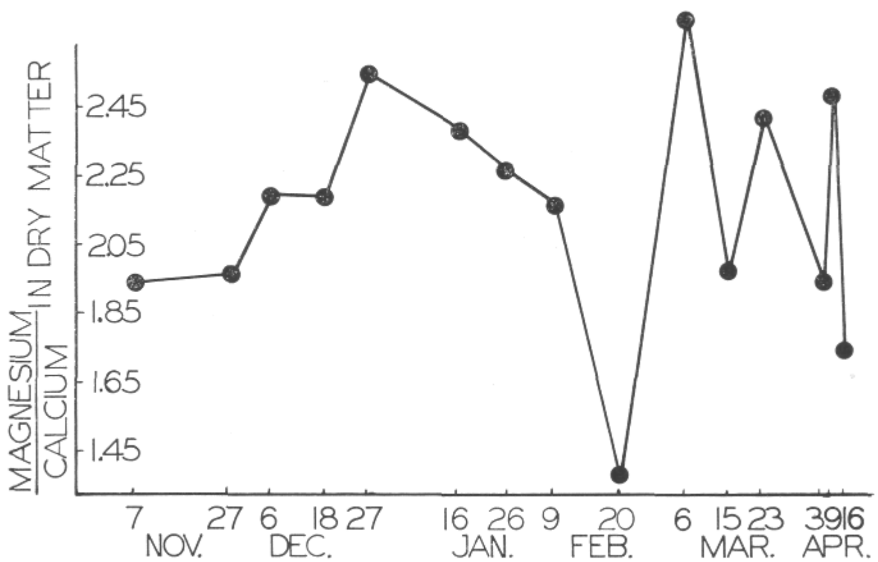

Fig. 8. *The magnesium-calcium ratio in the dry matter of the seed at various stages of seed development.*

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