Vanilla Culture in Puerto Rico

CIRCULAR NO. 28, Federal Experiment Station in Puerto Rico
UNITED STATES DEPARTMENT OF AGRICULTURE
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FEDERAL EXPERIMENT STATION IN PUERTO RICO

MAYAGUEZ, PUERTO RICO

Administered by the Office of Experiment Stations

Agricultural Research Administration

United States Department of Agriculture

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[1] In cooperation with the Government of Puerto Rico.

COVER ILLUSTRATION.—A promising method for growing vanilla in Puerto Rico. Sunlight is uniformly controlled throughout the year, growth and survival of plants are excellent, flowering heavy, livestock and meddlers are kept out, and management in general is greatly facilitated.

FEDERAL EXPERIMENT STATION IN PUERTO RICO

of the

UNITED STATES DEPARTMENT OF AGRICULTURE

MAYAGUEZ, PUERTO RICO

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VANILLA CULTURE IN PUERTO RICO

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CONTENTS

A crop such as vanilla is urgently needed in Puerto Rico to supplement or partially replace coffee which occupies about 100,000 acres of highland soil. Coffee growing in recent years has not flourished in Puerto Rico because of competition, hurricane damage, improper care, and other factors. The rehabilitation of much of the coffee land

[1] In preparing this bulletin the authors have received cooperation from vanilla growers, members of the Castañer Curing Plant, buyers, and others associated in one way or another with the industry. Among those who have given valuable assistance are: Graciano Archilla, Morovis; José Huyke, Morovis; Charles Pennington, Mayaguez; Domingo Serra, Ponce; Bartolomé Bauzá, Lares; Rafael Santiago Esbrí, Castañer; Louis L. de Vertueil and Leo Narodny, Dominica, British West Indies; Dr. Lewis Knudson of Cornell University at Ithaca, New York; Robert Rosenbaum, Philadelphia; Mary L. Bynum of the Bureau of Foreign and Domestic Commerce; Hugh W. Taylor of the United States Office of Foreign Agricultural Relations; and Luis Izquierdo, Commissioner of Agriculture of Puerto Rico. Félix Antonio Rosado, laboratory assistant in vanilla at the station, has aided in the drawings and compiling of data. Harold K. Plank offered suggestions on vanilla insects. Previous staff members working on vanilla at the Federal Experiment Station in Puerto Rico have directly or indirectly contributed by their experiences over the 38 years of vanilla research; their contributions are cited throughout the circular.

is probably the most important problem facing Puerto Rican agriculture today. On the island, as a whole, there is a density of population of over 500 persons per square mile. The almost complete dependency of these people upon agriculture makes it imperative to utilize all arable land to its highest productivity and with the greatest resulting profit.

The Federal Experiment Station at Mayaguez has conducted a research program with vanilla for over 38 years with the goal of making it at least a minor agricultural crop for the highland farmers. The recommendations given for vanilla culture in this circular are based not only on experimental results obtained at Mayaguez but on the experience of several cooperating vanilla growers located in different sections of the island under varying climatic and soil conditions. It has been amply demonstrated that vanilla can be grown profitably in Puerto Rico provided it is located on a suitable site and conscientious management is given.

Vanilla is unlike sugarcane and certain other tropical crops which can be planted, cared for a short time, and then more or less forgotten until harvest. Vanilla is similar to vegetables in requiring careful attention from the time of planting to harvest. In order to grow vanilla successfully in Puerto Rico a heavy mulch must be continually maintained, sufficient but not excessive light admitted through the shade trees, proper pruning of the support trees, and moderate but not excessive pollination. These and several other practices mentioned later are vital in successful vanilla culture in Puerto Rico. Unless such practices are followed, the vines become weak, low-producing, short-lived, and susceptible to root rot.

HISTORY

General.—Vanilla was first associated with Mexico. When Hernán Cortez and his followers entered Mexico early in the 16th century they discovered the Aztec Indians using vanilla for flavoring in chocolate. The Spaniards took samples of the vanilla home to Spain in about 1510, where a marked demand for it spread to France and other European countries.

By 1760 there had been a definite increase in vanilla production in Mexico. The botanical gardens in Europe as well as traders introduced vanilla cuttings into the following islands: Réunion (1793) [2], Java (1819), Bourbon (1822), Madagascar (1842), Tahiti (1848), Comores (1873), Mauritius (1880), and Seychelles (1890) (*5*).[3] Some difficulty was encountered in securing commercial crops of vanilla because of the fact that the vines set but few fruits. In Mexico where the plant was native, special insects, possibly bees (*11*), apparently brought about a certain amount of pollination. However, when a practical method of artificial pollination was discovered in 1841 by a former slave, Edmund Albius, in Réunion, and it was found also that it could be propagated by cuttings, the production of vanilla increased rapidly, especially in Madagascar and neighboring islands. The increased

[2] These dates have been found to vary a few years with different publications.
[3] Italic numbers in parentheses refer to Literature Cited, p. 77.

vanilla production in Madagascar at this time was further stimulated by a sugarcane failure between 1849 and 1856.

The Spanish, British, and French were all responsible for the dissemination of vanilla throughout the Tropics, but the French have undoubtedly exploited the crop more than any other people. France's largest colonial producer, Madagascar, is now responsible for over half of the world supply (table 1), with Mexico accounting for about one-fourth. For a more detailed account of the general history of vanilla, see the literature summary prepared by Correll (*4*).

Puerto Rico.—Vanilla is thought to be indigenous to Puerto Rico because wild plants, one of which was later identified as *Vanilla barbellata* Reich. (*18, p. 24*) were seen by McClelland (*12*) growing in the vicinity of Bayamón, Dorado, Lares, Maricao, Mayaguez, San Germán, Guánica, and Guayanilla. The commercial vanilla species was first introduced into Puerto Rico from Mexico by a relative of Miguel Morell of Utuado early in the 1900's (no date given).[4] Mr. Morell grew the plants only as a hobby. A second importation was made in 1909 by the Federal Experiment Station in Puerto Rico from the United States Plant Introduction Gardens in Florida. These two importations, so far as the literature reveals, are the sources of material from which most commercial plantings in Puerto Rico have been derived. By constant vegetative propagation a small vanillery was developed by McClelland at the Federal Experiment Station. Stem cuttings were distributed from this stock to numerous farmers, but only a few developed commercial vanilleries. In 1924, one grower, S. W. Marvin of Villalba, sold 1,375 pounds of cured vanilla beans at the relatively high price of $10 a pound. However, in October 1928 when his planting had become well established, the San Felipe hurricane swept the island with disastrous consequences and, like many other planters, he abandoned both his coffee and vanilla enterprises.

In 1935 interest in vanilla was again revived when the Federal Emergency Relief Administration initiated a project for the extensive planting of vanilla in the coffee districts. Cuttings of vanilla and the support tree, dwarf bucare (*Erythrina berteroana* Urban), were distributed to some 40 farmers. Supervision and instruction on the best methods of establishing a vanillery were given (*16*, *17*).

A few years later the above agency was liquidated and in its place the Puerto Rico Reconstruction Administration (PRRA) was organized. This latter agency intensified the distribution of propagating material until about 106 acres were planted to vanilla by 1937. Three years later there were 434 acres in vanilla owned by 168 farmers. A central cooperative curing plant (fig. 1) was constructed at Castañer, and a cooperative association was organized by the vanilla growers. Through this cooperative uniform classification, curing, and packing, the lack of which had been the chief factor in preventing the island from becoming a production center, was brought about.

Beginning April 1, 1946, the grower's organization, Cooperativa de Cosecheros de Vainilla de Puerto Rico (the Vanilla Growers' Coopera-

[4] McClelland, T. B. The present status of Puerto Rican vanilla. Agricultural Notes. [Processed.] P. R. Agr. Expt. Sta. (Mayaguez). July 15, 1924.

TABLE 1.—*Pounds of vanilla beans exported by leading countries from 1925 to 1945 (figures for Puerto Rico through 1947)*[1]

Year	French West Indies	French Oceania	Madagascar and Dependencies	Mexico	Netherlands Islands	Réunion	Seychelles	Puerto Rico
1925	69, 082. 2		905, 918. 2	323, 371. 4		133, 339. 8		
1926	76, 753. 6		1, 362, 486. 4	263, 663. 4		203, 266. 8		
1927	19, 965. 0		1, 086, 027. 8	243, 867. 8		190, 812. 6		
1928	19, 965. 0		1, 499, 055. 3	243, 731. 4		255, 503. 6	2, 884. 2	
1929	8, 052. 0		2, 402, 397. 8	206, 804. 4		216, 189. 6	10, 135. 4	
1930	2, 420. 0		1, 440, 450. 0	316, 267. 6	45, 062. 6	66, 440. 0	7, 999. 2	
1931	3, 291. 2		1, 753, 164. 6	317, 119. 0	39, 388. 8	110, 440. 0	2, 134. 0	
1932	7, 497. 6		1, 905, 325. 4	249, 937. 6	44, 679. 8	72, 600. 0	2, 743. 4	
1933	10, 707. 4	116, 600. 0	1, 450, 314. 8	119, 198. 2	20, 281. 8	46, 200. 0		
1934	13, 387. 0	226, 600. 0	1, 005, 853. 2	208, 617. 2	75, 880. 2	74, 580. 0	1, 060. 4	
1935	18, 255. 6	191, 400. 0	1, 017, 940. 0	170, 557. 2	39, 435. 0	42, 680. 0	259. 6	
1936	28, 267. 8	207, 240. 0	1, 193, 280. 0	358, 745. 2	36, 126. 2	138, 600. 0	1, 265. 0	462. 0
1937	33, 312. 4		688, 600. 0	321, 301. 2	6, 133. 6	149, 600. 0	1, 025. 2	800. 8
1938	23, 067. 0	[2] 250, 000. 0	829, 400. 0	335, 440. 6	29, 570. 2		4, 642. 0	37. 4
1939	36, 357. 2	453, 200. 0	[2] 670, 000. 0	271, 128. 0	12, 922. 8			57. 2
1940	[2] 20, 000. 0	264, 880. 0	[2] 526, 000. 0	468, 600. 0	48, 851. 0			862. 4
1941 [2]	[2] 9, 800. 0	465, 520. 0	[2] 716, 000. 0	572, 000. 0				1, 773. 2
1942	[2] 42, 000. 0	121, 508. 2	[2] 36, 000. 0	145, 675. 2				2, 119. 0
1943	[2] 10, 600. 0	228, 602. 0	[2] 214, 000. 0	404, 848. 4				4, 000. 0
1944	[2] 20, 000. 0	[2] 368, 000. 0	[2] 722, 000. 0	193, 058. 8				6, 016. 9
1945	[2] 38, 000. 0	[2] 148, 000. 0	[2] 674, 000. 0					5, 983. 5
1946								4, 095. 3
1947								±4, 600. 0
Average	24, 322. 9	253, 462. 5	1, 052, 295. 9	286, 696. 6	36, 212. 0	130, 788. 6	3, 414. 8	±2, 567. 3

[1] Exportation data from some countries during World War II were not available when this publication went to press. Exports from Dominica (not included) during World War II increased rapidly from a few thousand to 50,000 pounds or more (*14*). Data from United States Department of Commerce, United States Government, Washington, D. C.

[2] Data taken from statistics section, L'Agronomie Tropicale (Seine), vol. 1: No. 1–2, 1946.

FIGURE 1.—A vanilla curing and packing plant was erected at Castañer in 1938 as a part of the Puerto Rico Reconstruction Administration Program. It is the center of activity of most of the Puerto Rican vanilla growers who send their beans from a radius of about 75 miles for uniform curing and packing.

tive of Puerto Rico), leased the curing plant from the Puerto Rico Reconstruction Administration for a 10-year period. A buying option clause was inserted in case purchase of the curing plant by the grower's organization seemed desirable and possible.

MARKET SITUATION

General.—The large vanilla crop from Madagascar more or less governs the world price from year to year. Most other countries, including Mexico, tend to follow the world price and market situation rather than create them. In 1914, before World War I, vanilla was used primarily in the baking trade, but the war brought about a drastic increase in price of vanilla as shown in figure 2. This increase in price was due to general wartime price advances and to reduced supplies from distant sources. Artificial vanilla, or "vanillin," was substituted for real vanilla in the baking trade and this was a heavy blow to the pure vanilla industry. Since that time, however, the ice cream industry has expanded considerably until the production of vanilla ice cream reached an annual figure of around 333,000,000 gallons in 1945. About half of the vanilla ice cream is flavored with true vanilla and the rest with vanillin.[5] The dairy industry through

[5] R. B. Stoltz, Chairman, Department of Dairy Technology, Ohio State University, Columbus, Ohio. 1946.

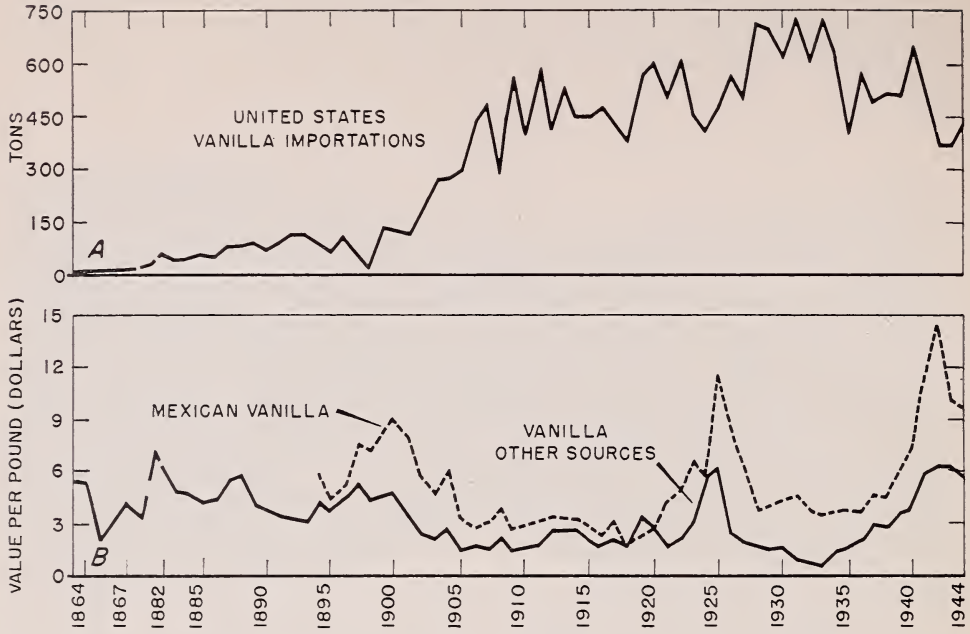

FIGURE 2.—*A*, importation of vanilla beans into the United States from 1864 to 1944, inclusive, and *B*, average prices paid for Mexican vanilla and for vanilla from other sources. Mexican beans usually bring a premium, particularly during peacetime.

ice cream is probably now the major consumer of pure vanilla. The relative importance of vanilla flavoring in ice creams is shown in table 2. The approximate utilization of vanilla beans by different industries is shown in table 3. Although the production of synthetic vanillin has created considerable competition for pure vanilla, the pure product still holds a much preferred position because the extract

TABLE 2.—*The relative importance of vanilla flavoring in ice cream in the United States (from data of The International Association of Ice Cream Manufacturers, Washington, D. C.).*

Flavor	Consumption per year		
	1925	1931	1938
	Percent	*Percent*	*Percent*
Vanilla	55. 48	48. 46	51. 26
Chocolate	10. 06	16. 78	16. 36
Strawberry	7. 82	8. 27	7. 95
Peach	2. 39	2. 27	1. 46
Cherry	3. 51	1. 98	1. 01
Maple	3. 36	1. 62	1. 07
Coffee	2. 26	. 20	. 62
Pineapple	----------	1. 50	. 91
Burnt almond	----------	1. 18	. 17
Butter pecan	----------	----------	3. 67
Others	15. 12	17. 74	15. 52

TABLE 3.—*Approximate utilization of pure vanilla by various industries, 1942* [1]

Industry	Vanilla used	Industry	Vanilla used
	Percent		*Percent*
Ice cream and dairy	40	Packaged foods	5
Household use	25	Baking (commercial)	5
Confectionery	8	Soft drinks	5
National defense units	6	Perfumery	5
Chocolate	5	Drug	5

[1] ROSENBAUM, R. In correspondence from The David Michael Co., Philadelphia. 1946.

from vanilla beans contains a combination of flavors and aromas which is judged by experienced consumers to be far superior to the synthetic product. Sometimes the pure vanilla is blended with the synthetic product to instill these special aromas. Extracts of this kind must be labeled "imitation vanilla" if they contain artificial coloring, or, "vanilla vanillin extract," if no such coloring has been added.

Production of synthetic vanillin in the United States from 1930 to 1944 is shown in figure 3. The amount of synthetic vanillin imported into the United States is insignificant, ranging between 125 and 505 pounds annually from 1930 to 1941, inclusive. Synthetic vanillin is produced from waste sulfite liquor of paper mills, coal tar extracts, and

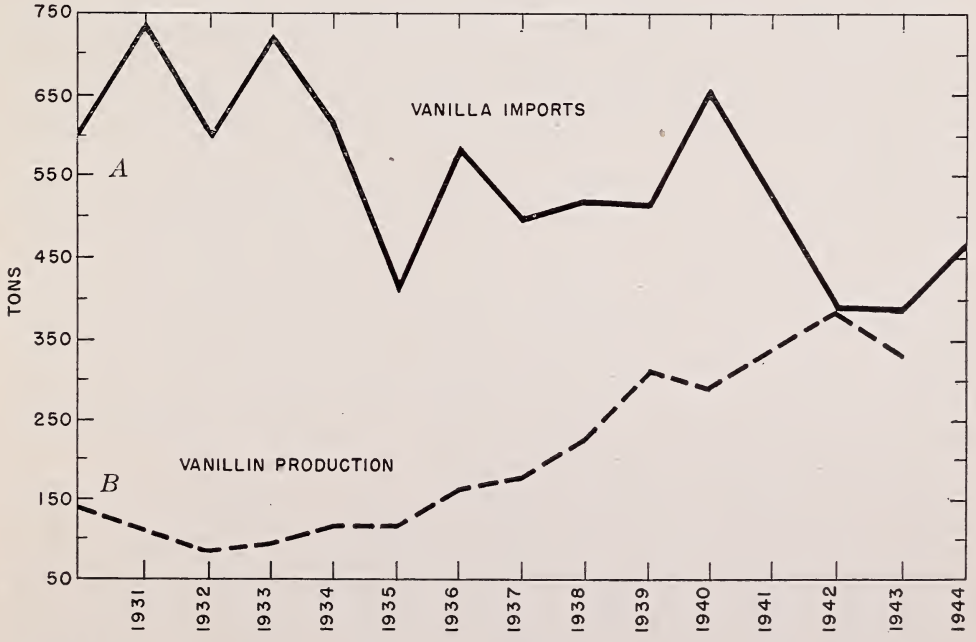

FIGURE 3.—*A*, Trends in importation of vanilla beans into the United States; and *B*, the utilization of artificial vanillin. Graphs show largest quantity of vanillin was manufactured in the United States. Impaired shipping during World War II caused the drop in vanilla bean importation from 1940–45.

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from eugenol obtained from clove oil. There is some indication that it can be prepared from eugenol obtained from bay oil. The price per pound of vanillin shortly after World War II in December 1945 was $2.60 when extracted from eugenol; and $2.35 from lignum. In the same price quotation Mexican whole vanilla beans were bringing $10.50 to $11 per pound packed in tins. Puerto Rican vanilla was bringing $7.50 to $8.50 a pound. It is apparent that synthetic vanillin is a relatively low-priced product and that in some years it is possible to buy 50 pounds of vanillin for the price of 1 pound of the natural vanilla product (*25*).

Although Mexico produces about one fourth of the vanilla beans imported into the United States as shown in table 4, it is estimated (*10*) that the country is capable of producing 1,000,000 pounds, or a quantity sufficient to meet most of the requirements of the United States. It is reported further that there is sufficient land as well as labor available for increasing this figure to over 2,000,000 pounds, if the market demanded it. In the principal Mexican producing areas, which consist of the states of Veracruz, Puebla, Tabasco, Chiapas, Oaxaca, and San Luis Potosí, the 10-year average production between 1929 and 1939 was 314,000 pounds. In 1940 to 1941 production reached 476,000 pounds. However, the vines were severely damaged during World War II due to adverse weather conditions, mainly drought, and excessive pollination to obtain large crops (*10*). The place that Mexico will hold in the postwar world market will depend upon the comeback in production in the French possessions, primarily Madagascar, and also on changes in trade agreements with the United States and other countries.

Under the trade agreement made in 1943 (*24, pp. 124–125*), a duty of 12½ cents per pound is imposed on French vanilla entering the United States and 15 cents on Mexican vanilla. There is no duty on vanilla coming from Puerto Rico because it is a possession of the United States, and this is a distinct advantage to the Puerto Rican growers.

Puerto Rico.—Since 1935, vanilla production in Puerto Rico has increased definitely, although the industry still is relatively small (see table 1 and figures 4 and 5). In 1944–45 the value of the crop rose to $40,000. A recent survey showed a total of about 144 active growers, the majority of whom are associated with the vanilla growers' cooperative. The largest producer among these growers sold 2,332 pounds of fresh beans to the Cooperative in 1944–45. As indicated in table 5 prices for vanilla were exceptionally good during the war period because of partial cessation of foreign shipments to the United States, mainly from Madagascar.

With the modern curing and packing plant at Castañer the vanilla industry in Puerto Rico has a good foundation for future expansion. Through this medium it is possible to prepare a uniformly graded and packed Puerto Rican product. One of the handicaps in some important vanilla-producing countries is the wide variation in quality and pack of beans arriving at the New York market. The Mexican product, however, is prepared with great care. A special procedure is followed in bundling and packing, and this extra effort has paid good dividends and developed greater confidence in the product among buyers.

TABLE 4.—*Importation of vanilla beans into the United States by countries from 1933 to 1945* [1]

Country	Year												
	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
France [2]	1, 204, 725	866, 653	591, 082	670, 337	480, 263	427, 623	299, 623	213, 200	18, 701	-------	-------	-------	-------
Netherlands [2]	-------	9, 370	2, 659	15, 514	1, 084	-------	100	-------	-------	-------	-------	-------	-------
United Kingdom [2]	1, 322	5, 972	2, 784	4, 447	5, 008	-------	-------	-------	-------	-------	-------	-------	-------
Canada [2]	423	2, 414	-------	2, 623	17	-------	-------	-------	-------	-------	-------	-------	-------
Mexico	98, 486	133, 864	118, 531	260, 725	267, 706	196, 520	270, 117	370, 987	576, 836	138, 598	222, 830	449, 937	534, 460
Barbados [2]	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	1, 000	-------
Trinidad and Tobago [2]	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	155	100	1, 698
Other British West Indies (largely Dominica)	-------	4, 826	91	2, 356	3, 727	7, 058	8, 125	8, 406	9, 939	13, 744	23, 945	43, 015	-------
French West Indies	8, 469	4, 476	11, 801	16, 006	19, 168	10, 293	25, 639	23, 491	31, 526	24, 344	7, 452	7, 217	-------
Netherlands Indies	15, 283	54, 739	35, 087	28, 736	12, 939	13, 279	12, 664	17, 021	83, 364	19, 996	-------	-------	-------
French Oceania (largely Comores and Réunion)	24, 235	38, 808	25, 367	25, 607	24, 483	21, 498	115, 675	154, 122	199, 657	185, 503	115, 516	170, 956	171, 620
Madagascar	135, 319	119, 368	41, 223	137, 760	174, 773	338, 934	272, 876	493, 992	87, 593	372, 468	368, 316	231, 467	793, 206
Other French Africa	-------	3, 655	-------	-------	5, 939	8, 321	11, 886	27, 445	-------	-------	-------	-------	-------
Denmark [2]	-------	-------	-------	22	22	-------	11	-------	-------	-------	-------	-------	-------
Chile [2]	-------	-------	-------	11	-------	-------	-------	-------	-------	-------	-------	-------	-------
British India [2]	-------	-------	-------	1, 280	-------	-------	-------	-------	-------	-------	-------	-------	-------
Brazil	-------	-------	-------	-------	516	-------	-------	928	9, 652	751	-------	-------	-------
Puerto Rico	-------	-------	-------	-------	-------	-------	57	864	1, 778	-------	-------	-------	-------
Ceylon	-------	-------	-------	-------	-------	874	-------	-------	-------	-------	-------	-------	-------
British East Africa [2]	-------	-------	-------	-------	-------	-------	389	1, 220	262	7, 671	100	-------	2, 496
Guatelama	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	18	-------	3
Haiti	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	3
Dominican Republic [2]	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	2, 054	1, 059	-------
British Oceania [2]	-------	-------	-------	-------	-------	-------	-------	-------	22	-------	-------	-------	-------
Union of South Africa [2]	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	601	-------	-------
Seyschelles (Br.)	-------	-------	-------	-------	-------	-------	-------	9, 548	568	1, 254	7, 599	6, 497	2, 259

[1] Data from United States Department of Commerce.

[2] Undoubtedly reshipments from other countries.

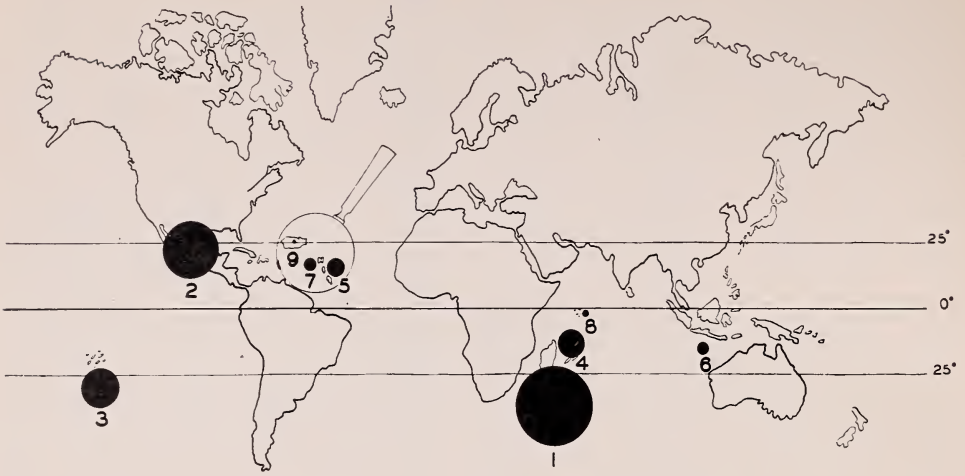

FIGURE 4.—The relative production of vanilla by country is shown on the basis of average figures from available data in table 1. Islands in the West Indies have been magnified, but not the black circles. The figures indicated may vary considerably from year to year and, therefore, serve only as an approximate index of the relative importance of each country in world production. Note that vanilla is produced within an area 25° above and below the Equator.

Future prices are bound to fluctuate with the supply and demand for vanilla. The lowest recorded price for vanilla on the United States market was $1.90 in 1930 and the highest price was $14 in 1941. The average price for vanilla over 45 years, from 1900 to 1945, inclusive, was slightly over $2 a pound. However, it could hardly be recommended that the grower raise only vanilla when prices are high, and discontinue growing it when they are low. A diversified farm, rather than one restricted to one or two crops, is usually a better business proposition in the long run where several crops such as coffee, tobacco, bananas, possibly vegetables, bay trees, and similar crops are maintained, thus enabling the grower to quickly stress one or the other, depending upon the market situation. A practice similar to this has

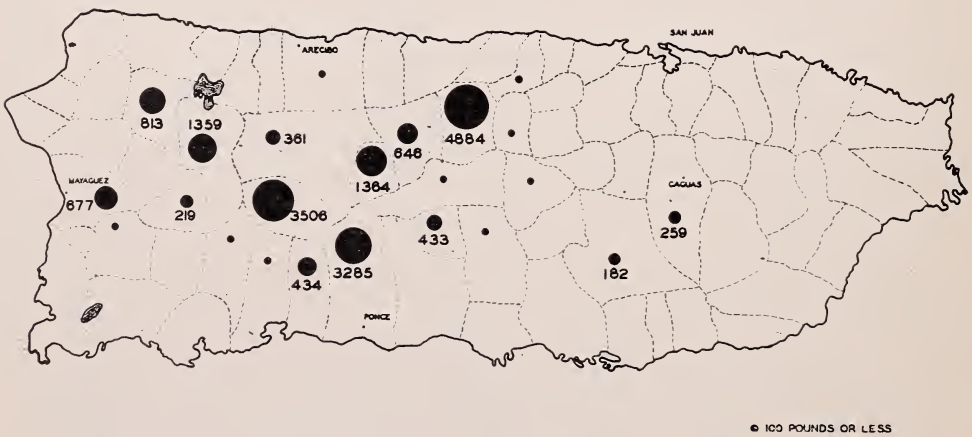

FIGURE 5.—Most of the vanilla is grown in the central western section of Puerto Rico in the mountainous regions. Average annual production per municipality, as indicated by respective figures, is based on the 4-year-period 1941–44, inclusive. Leading municipalities are: Morovis, Adjuntas, Ponce, Jayuya, and Lares, in the order listed.

been followed for years in Mexico where the Indians have always maintained a certain amount of vanilla plantings, increasing production when it was justifiable, as during World War II (*10*).

TABLE 5.—*Prices paid on the United States market for different types of cured vanilla beans by quarters, 1934–45, inclusive* [1]

Year and quarter	Type				
	Bourbon	Mexican whole	Mexican cuts	Tahitian	Puerto Rican
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1934					
First	0. 90	3. 00	2. 30	---	---
Second	1. 40	3. 00	2. 15	---	---
Third	2. 25	3. 00	2. 50	---	---
Fourth	2. 00	3. 60	3. 30	---	---
1935					
First	2. 75	3. 75	3. 00	---	---
Second	2. 25	3. 30	3. 00	---	---
Third	1. 85	3. 25	2. 70	---	---
Fourth	2. 00	3. 00	2. 70	---	---
1936					
First	2. 25	2. 60	2. 30	---	---
Second	3. 00	3. 00	2. 75	---	---
Third	2. 75	2. 90	2. 75	---	---
Fourth	3. 10	3. 00	3. 00	---	---
1937					
First	3. 50	3. 50	3. 25	---	---
Second	4. 50	4. 50	4. 00	---	---
Third	4. 35	4. 35	4. 25	---	---
Fourth	3. 85	4. 30	4. 00	---	---
1938					
First	3. 10	4. 00	3. 45	---	---
Second	3. 25	4. 25	3. 45	2. 70	---
Third	3. 65	4. 15	3. 50	---	---
Fourth	3. 75	4. 25	4. 00	---	---
1939					
First	4. 75	4. 75	4. 55	---	---
Second	5. 45	5. 40	4. 85	2. 40	---
Third	5. 50	5. 50	5. 25	---	5. 00
Fourth	6. 25	6. 30	6. 00	2. 75	5. 00
1940					
First	5. 60	6. 15	5. 45	2. 75	---
Second	5. 70	5. 90	5. 55	3. 00	---
Third	6. 25	6. 50	6. 25	3. 25	6. 65
Fourth	7. 00	7. 00	6. 85	3. 45	6. 65
1941					
First	9. 20	8. 75	7. 60	5. 60	---
Second	9. 45	8. 80	7. 75	4. 80	---
Third	9. 25	9. 00	8. 00	5. 25	9. 50
Fourth	9. 25	9. 50	8. 75	5. 40	9. 50

[1] Data from Oil, Paint, and Drug Reporter for 1934–45, inclusive, Schnell Publishing Co., Inc., New York 7, N. Y.

TABLE 5.—*Prices paid on the United States market for different types of cured vanilla beans by quarters, 1934–45, inclusive*—Continued

Year and quarter	Type				
	Bourbon	Mexican whole	Mexican cuts	Tahitian	Puerto Rican
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1942					
First	9. 75	10. 50	9. 75	6. 25	10. 00
Second	10. 00	11. 50	10. 75	6. 50	10. 00
Third	10. 00	11. 00	10. 00	6. 50	10. 00
Fourth	10. 00	11. 00	10. 00	5. 00	10. 00
1943					
First	7. 75	9. 25	8. 25	4. 75	----------
Second	7. 75	9. 00	8. 00	3. 75	----------
Third	7. 75	8. 25	7. 70	3. 50	6. 60
Fourth	7. 75	8. 25	7. 70	3. 50	6. 60
1944					
First	7. 75	8. 25	7. 70	3. 50	----------
Second	7. 75	8. 25	7. 70	3. 50	----------
Third	7. 75	8. 25	7. 70	3. 50	6. 80
Fourth	8. 00	----------	----------	3. 50	6. 80
1945					
First	----------	----------	----------	----------	----------
Second	----------	----------	----------	----------	----------
Third	----------	----------	----------	----------	7. 50
Fourth	8. 02	10. 75	9. 75	3. 50	7. 50

In the over-all picture it should be taken into consideration that the world crop of vanilla is normally worth around $10,000,000, or about one-sixth the value of the sugarcane crop in Puerto Rico. Thus, vanilla production in Puerto Rico can hardly be more than a minor agricultural enterprise.

BOTANY OF VANILLA

Vanilla is a tropical climbing orchid which belongs to the family Orchidaceae. It is closely related, therefore, to the orchids which are grown and sold in the floral industry for the beauty of their flowers. Vanilla is often referred to as the "orchid of commerce." Over 50 species have been described, but only 3 are commercially important: (1) *Vanilla fragrans* (Salisb.) Ames (*V. planifolia* Andrews), (2) *V. pompona* Schiede, and (3) *V. tahitensis* J. W. Moore.

Vanilla fragrans (fig. 6) is by far the most important commercially. It is said to be indigenous to southeastern Mexico, the West Indies, Guatemala, El Salvador, Panama, British Honduras, Nicaragua, Costa Rica, Colombia, Venezuela, Surinam, British Guiana, French Guiana, Ecuador, Peru, and Bolivia (*4*). It is widely cultivated

throughout the Tropics. Correll (*4*) gives the following botanical description of *V. fragrans*:

A coarse vine that, in nature, climbs to the tops of tall trees.[6] Stem simple or branched, long, flexuous, succulent, green, producing opposite the leaves twining adventitious aerial roots by which it clings to the tree and other supports; leaves succulent, nearly sessile, oblong-elliptic to narrowly lanceolate, acute to acuminate, 9 to 23 cm. long, 2 to 8 cm. wide; racemes axillary, consisting of as many as 20 or more flowers which are greenish yellow and inconspicuous; flowers composed of three sepals, three petals, and a central organ known as the column (the united stamen and pistil), with one of the petals modified and enlarged to form the lip; sepals and petals almost linear to oblong-oblanceolate, obtuse to

FIGURE 6.—*Vanilla fragrans* (Salisb.) Ames is the only commercial variety of vanilla grown in Puerto Rico. The long narrow beans have superior aroma and quality and bring the best prices on the market.

subacute, 4 to 7 cm. long, 1 to 1.5 cm. wide; lip trumpet-shaped, attached almost to the apex of the column which it envelopes, somewhat 3-lobed above, 4 to 5 cm. long, 1.5 to 3 cm. wide at the widest point, with longitudinal verrucose lines or papillae on the disc and a tuft of hairs about the middle of the disc, retuse at the apex and irregularly fringed on the revolute margin; column hairy on the inner surface, about 3 cm. long; fruit a capsule (commercially known as a "bean"), narrowly cylindrical, 1 to 2.5 dm. long, 8 to 14 mm. in diameter.

The less important *Vanilla pompona* (fig. 7) is sometimes called vanillon, West Indian, South American, or pompona vanilla. It is

[6] Vanilla has been seen at a height of 50 to 75 feet on trees (*Albizzia procera* Benth.) in Puerto Rico.

indigenous to Central America, Trinidad, southeastern Mexico, and northern South America. Cultivation is chiefly in Guadeloupe, and to some extent in Dominica and Martinique. *V. pompona* will grow under somewhat more adverse moisture and soil conditions than *V. fragrans* and seems to be more resistant to the root rot disease (*Fusarium batatatis* var. *vanillae* Tucker). Pompona vanilla forms flowers 1 or 2 years after planting whereas *V. fragrans* usually flowers the third year. *V. pompona* resembles *V. fragrans* except that the leaves are larger, being 15 to 28 cm. long and 4 to 11.5 cm. wide. The flowers are greenish yellow and larger as well as more fleshy, and the lip has a tuft of imbricating scales instead of hairs in the center of the disk. The beans are triangular and more fleshy thickened, being 15 to 17.8 cm. long, and 2.5 to 3.3 cm. in diameter. They show little or no tendency to split at maturity. Quality of the pompona beans is inferior

FIGURE 7.—*Vanilla pompona* Schiede, sometimes called "vanillon" or "pompona," is relatively resistant to the root rot disease and does not split when mature; it is being used as a parent with *V. fragrans* for developing improved varieties. Chief disadvantages of the beans are inferior quality and low market price.

to *V. fragrans* and consequently they bring a lower price on the market. The flavoring is commonly used in smoking tobacco, soaps, perfumes, medicines, liquors, cordials, and for blending with extract made from *V. fragrans*.

Vanilla tahitensis is indigenous to Tahiti and is the source of Tahitian vanilla coming from the French Oceania group of islands in the Pacific Ocean. It is also cultivated in Hawaii. Tahitian vanilla brings a lower price on the market than *V. fragrans*. It differs from *V. fragrans* by having more slender stems, narrower leaves, longer perianth segments, and a lip that is shorter than the stipule sepals. The pods are shorter than those of *V. fragrans*, reddish brown and 12 to 14 cm. long, 9 mm. in width, broad in the middle and tapering toward the ends (*4*).

At the Federal Experiment Station in Puerto Rico several other species of vanilla are maintained for the purpose of cross-breeding

with *Vanilla fragrans* to obtain seedlings with possibly greater resistance to vanilla root rot. In addition to *V. pompona* which is relatively resistant to the root rot, two other species, namely *V. phaeantha* Reich. f. and *V. barbellata* Reich., have been apparently free from attack.

The fruits of *Vanilla phaeantha* (fig. 8) are only 3 to 4 inches in length, subcylindrical, and larger at the apex than at the base. *V. barbellata*, as shown in figure 9, is distinctly different from the other species mentioned in that it has very small bract-like leaves. This species is more or less a curiosity in the vanilla group. It is relatively weak in vigor, probably as a result of its limited photosynthetic area.

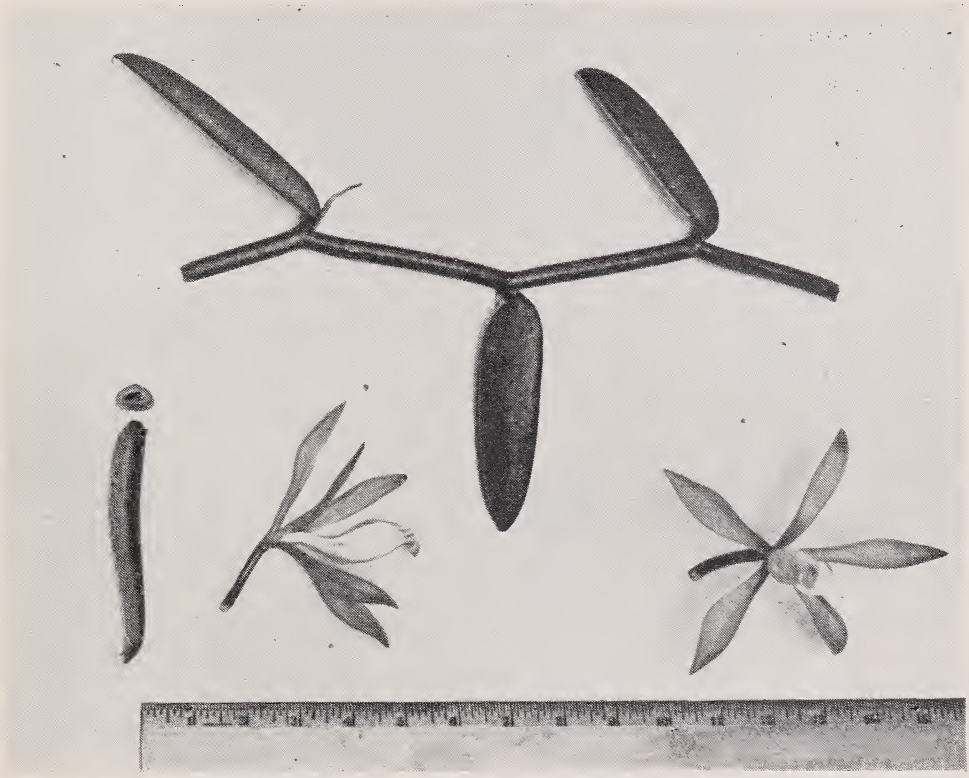

FIGURE 8.—The beans of *Vanilla phaeantha* Reich. f. are short, subcylindrical, and larger at the apex than at the base. The leaves are less pointed than those of *V. fragrans*.

The flower clusters contain less than 10 flowers. The pod is medium-sized, cylindrical, somewhat spongy, and tapers to either end.

ESTABLISHING A VANILLERY

Climate.—Vanilla requires a warm, moist, tropical climate with frequent but not excessive rains. A short low-rainfall period of about 6 to 8 weeks seems to be important during the period of ripening of beans and flowering. Vanilla, however, cannot withstand extended periods of dryness or strong winds. Excessive moisture throughout the year resulting in more or less continually moist vines is not desirable, mainly from the standpoint of diseases.

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As shown in figure 4, most of the vanilla, except for Mexico, is produced on islands from within a few degrees of the Equator to about 25 degrees north and south of it. Puerto Rico is bisected by the 18th parallel of latitude north of the Equator and falls within these limits. In Puerto Rico vanilla is grown from sea level to an altitude of 2,500 feet or more.

In the West Indies vanilla is growing successfully under annual rainfall conditions varying from about 75 to 200 inches.[7] Value of the rainfall, however, is measured not so much by the total inches as by the distribution throughout the year. At Mayaguez, in most years, the dry periods have been too extended during the winter season for

FIGURE 9.—*Vanilla barbellata* Reich. is relatively weak in vigor as evidenced by the small leaves and low production of beans. The flower has a dark purple fringe around the labellum. The beans are short and taper to both ends.

successful vanilla growing, except in the most sheltered areas or where irrigation is available. One exceptionally dry period during the life of the vanilla plant may either result in death or so weaken the plant that it will be of little economic value thereafter. In Puerto Rico, as well as in Mexico (*10*), drought is probably the worst enemy of vanilla.

One of the more successful regions for production of vanilla in Puerto Rico, as demonstrated over some 35 or more years, is near Morovis, where the annual rainfall is more evenly distributed than at Mayaguez (fig. 10). The climate is undoubtedly too dry for vanilla

[7] Personal communication from Louis de Vertueil, Superintendent of Agriculture of Dominica, British West Indies. 1946.

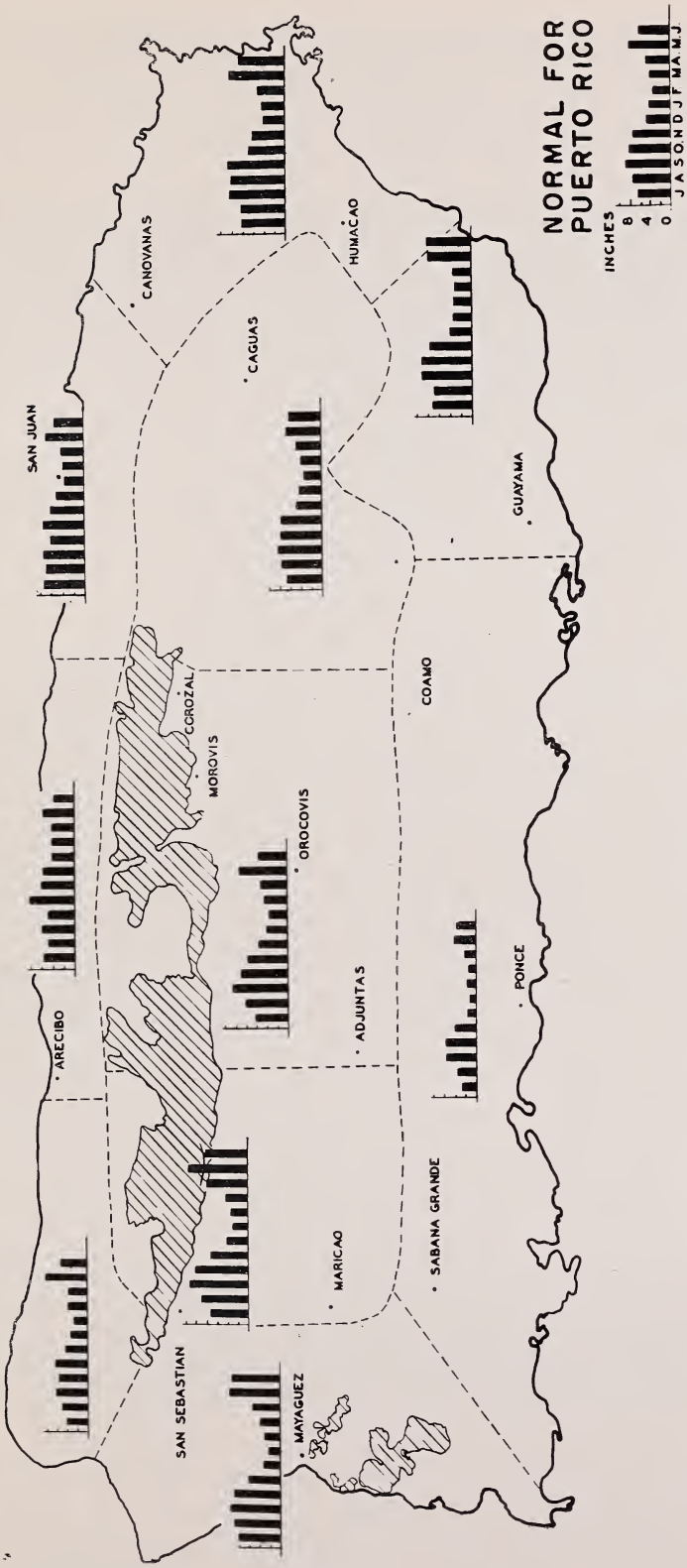

FIGURE 10.—Annual rainfall varies considerably over Puerto Rico with some areas on the south coast receiving 20 to 30 inches, and others near the Luquillo Forest at the eastern end of the island receiving over 200 inches. The more successful vanilleries are located in the region of Morovis, where the rainfall is well distributed over the 12-month period varying between 75 and 85 inches. Cross-hatched areas show soil regions relatively high in pH. The northern strip is of limestone origin. On the basis of experience near Morovis, this type of soil appears to be favorable to vanilla growing.

in most areas along the southwest coast where the irregular rainfall totals from 20 to 50 inches. Rainfall conditions in and around some regions of the Luquillo Forest on the eastern end of the island appear to be desirable for vanilla cultivation, but to this date no known trials have been made in this area. There are localities in the Luquillo Forest where annual rainfall is around 130 inches with 5 to 8 inches falling per month during the so-called "dry" months.

The average temperature conditions in Puerto Rico more or less coincide with those in other countries where vanilla is successfully grown. Over a period of 35 to 40 years the mean average daily temperature has been at Mayaguez, 77.2° F.; Arecibo, 77.6°; Corozal, 76.0°; Caguas, 76.5°; Guayama, 79.9°; Jayuya, 74.6°; and Maricao, 72.0°. The average maximum temperature in these regions varies between 83° and 89° and the average minimum between 60° and 65°, with the lowest minimum usually occurring in January or February. This is similar to the climates reported for the Seychelles Islands, Tamatave, Madagascar, and Veracruz, Mexico, where the mean temperatures vary from 70° to 80° (*21, pp. 23–93; 20, pp. 673, 682*).

SOIL REQUIREMENTS

When selecting a soil for vanilla it is important to consider also rainfall conditions and land slope. If rainfall is heavy several months of the year and the land is more or less level, the well-drained gravelly or sandy loam soils rich in humus are the more desirable. The heavy types of soil with slight slope or no slope tend to waterlog under 75 to 80 inches of annual rainfall, whereas the gentle slopes are more satisfactory in shedding an overabundant water supply. This is borne out by the results obtained at Mayaguez and Morovis.

It is important that the subdrainage conditions of the soil also be good. Vanilla is a relatively shallow-rooting plant as shown in figure 11, but if the subsoil is poorly drained, the surface layers remain more or less saturated during the rainy season and this results in the death of many of the roots. In the dry season the poorly drained soils are subject to cracking, followed by rapid drying.

In Puerto Rico the soils which appear to be best for vanilla are of limestone origin with a pH between 6.0 and 7.0 A large area of soils of this type is located in the vicinity of Morovis and Ciales in the north central section of the island as indicated in figure 10. They are known as the Soller and Plata clay series. A cross section of the Soller type is shown in figure 12. There are other desirable soils that are similar from the standpoint of texture and pH, such as the Múcara clay loam near Ponce and the Toa clay found mainly along lowland streams. A number of vanilleries are located on Catalina clay soil, but in general, vanilleries on this soil type have not been so successful for vanilla as those on soils of limestone origin. It is not known whether this is due to lack of certain nutrients in the soil or to some other factor such as rainfall distribution, which may be more important than the soil type itself. It is known, however, that the calcium and phosphorus contents of Catalina soil are relatively low (*22*), and that the pH is also low, around 5.5 or less. A combination of some or all of these factors may be responsible for the better results obtained on soils of limestone origin.

Vanilla has been grown on rocky limestone slopes in Puerto Rico, but for the plant to be successful under these conditions, there must be adequate moisture throughout the year and considerable soil among the crevices. The plant shown in figure 13 was photographed near Morovis, growing in a moderate shade of tall trees.

FIGURE 11.—In the heavier type of soil upon which most of the vanilla is grown in Puerto Rico, the roots penetrate to a depth of about 2 to 4 inches beneath a lightly mulched plot such as that here shown, and to a less depth under a heavy mulch. Thus, it is highly important to maintain a heavy mulch continously to prevent the soil from drying during periods of low rainfall. Also, the soil must be well drained to prevent the rooting area from becoming waterlogged during periods of heavy rainfall.

FIGURE 12.—The Soller clay loam series near Morovis appears to be well adapted to vanilla growing. This soil is of limestone origin. The profile here illustrated shows a surface layer of about 4 to 6 inches which is high in organic matter and humus and below which is 4 feet or more of a reddish brown clay permeated with limestone rock.

FIGURE 13.—A vigorous vanilla plant (*Vanilla fragrans*) growing in the soil-filled crevices of limestone rock. Such a plant can be grown only where there is adequate soil in the crevices and rainfall and shade are favorable.

VARIETIES

The only variety of vanilla grown commercially in Puerto Rico is *Vanilla fragrans*. *V. pompona* can be grown successfully and, in fact, has been more resistant to adverse conditions of soil and drought at the Federal Experiment Station than *V. fragrans*. As stated earlier, however, the pompona beans are of low quality and bring a low price which would probably not be worthwhile under the conditions of relatively high labor costs prevailing in Puerto Rico.

SITE AND PREPARATION

Selection of a good site is of prime importance in successful vanilla culture in Puerto Rico; in fact the location of the site may make the

FIGURE 14.—The site shown is favorable for vanilla because it has an eastern exposure and is protected on three sides by hills. The slope is about 15 percent. Dwarf bucare is the support tree.

difference between success or failure in the venture. Figure 14 shows a site on which vanilla has been successfully grown over a period of at least 12 years. The land has an eastern exposure with a moderate slope for good drainage. It receives the morning sun but escapes some of the afternoon sun which falls behind the hill at about 4 p. m. In winter the sun is lower toward the south and strikes the plants more at an angle. The vanillery is surrounded on three sides by hills and, therefore, receives protection from continuous winds and hurricanes.

In general, observations in Puerto Rico show that the more successful vanilleries are located on concave slopes and nearer the base of

the slope than the top. It is not wise to plant a vanillery where it will be exposed to more or less continuous drying winds. On sites where winds tend to be continuous in some seasons it may be well to plant a windbreak hedge to protect the vanilla. Red hibiscus or a plant that retains its leaves throughout the year can be used.

If the site chosen for vanilla is in dense timber or has been in coffee, the underbrush should be largely eliminated and the tall trees spaced from 15 to 25 feet apart to admit about 50 percent sunlight. Such areas are particularly desirable because the soil surface is usually covered with a heavy layer of rich humus and organic matter. The vanilla can be trained upon the trunks of the shade trees, or, better, on selected low-growing support trees which can be planted in advance or at the same time that the vanilla is planted.

SUPPORT TREES FOR VANILLA

Various species of living trees have been used for vanilla supports but it is not uncommon to find other types of supports such as trellises, lattice work, and posts with wire or iron bars. The latter supports may be objectionable because they tend to "cut" the heavy vanilla vines. Also, lattice work, posts, and iron supports may deteriorate rapidly under tropical conditions.

A good support tree for vanilla in one country or region may not be adapted to another region; the selection must depend to a large extent upon its adaptation to local conditions. A dwarf living tree or bush is probably most satisfactory because it requires relatively less pruning attention after planting. The ideal support tree would be one that may be readily propagated, is a fairly fast grower, a legume, dwarf in size, sufficiently strong to support the weight of the plant and sufficiently deep-rooted to resist heavy winds, has regular and low branching, does not provide too dense a shade, has medium to small leaves which do not drop severely during dry periods, and that is not subject to serious attacks by insects and diseases. A plant which can be propagated from large-size cuttings is more desirable than one grown from seed. Dwarf bucare (*Erythrina berteroana* Urban) which is widely used in Puerto Rico for a support tree, answers most of the above descriptions under certain environmental conditions. During the rainy season the shade is quite satisfactory (fig. 15). However, during the dry season it has the distinct disadvantage of losing most of its leaves as shown in figure 16. Dwarf bucare alone as a shade and support tree appears to be definitely unsatisfactory at Mayaguez, whereas at Morovis where the winter rainfall is higher and more even, the tree tends to retain somewhat more of its leaves. Under Morovis conditions, however, dwarf bucare undoubtedly admits too much light and heat to the leaves during the dry season when the vanilla needs protection most.

Economic trees such as coffee, mango, avocado, and citrus have been suggested for support trees for vanilla. However, they have a definite disadvantage in that the pickers of the fruit may injure and expose the vanilla roots by walking on them. It is possible to reduce this damage by building a 1-foot-high fence, 4 to 5 feet in diameter, of dwarf bucare

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FIGURE 15.—Dwarf bucare is used as a support and shade tree in this block of vanilla near Morovis. Note good growth of vanilla and bucare with adequate space between the clumps for free operation of workmen. Mulch is maintained around vanilla roots by a small bucare fence.

or hibiscus cuttings about the base of the vanilla and the support tree.

A leguminous support tree is desirable because it furnishes a certain amount of nitrogen to the vanilla roots. Roots of a legume bear nodules containing bacteria which have the power to assimilate nitrogen from the atmosphere. A part of this nitrogen is released into the neighboring soil; also, the leaves which are used for mulch are high in nitrogen.

An unidentified species of hibiscus is being used as a support tree in Dominica and appears to be satisfactory.[8] It retains most of its leaves

FIGURE 16.—The chief disadvantage of dwarf bucare (*Erythrina berteroana* Urban) as a support tree for vanilla is that its leaves drop during the dry season. This dropping can be checked to some extent, but not entirely, by heavy pruning at the end of the rainy season.

during the low-rainfall season. The cashew nut tree (*Anacardium occidentale* L.) has been tried on Las Mesas near Mayaguez, P. R., and shows promise in this locality.

In Mexico the cat-nut tree (apparently *Tabernaemontana citrifolia* L.) is frequently used by growers. In Puerto Rico the "pomarrosa" (*Caryophyllus jambos* (L.) Stokes) and the mango are not particularly desirable because scale insects that feed on these trees release a honey dew which falls on the leaves of vanilla and causes a black fungus growth as shown in figure 17. This black coating on the leaf may indirectly affect the physiological processes of the plant. Such a coating on the beans also necessitates special cleaning before curing.

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[8] Louis de Vertueil, Superintendent of Agriculture, Dominica, British West-Indies. 1946.

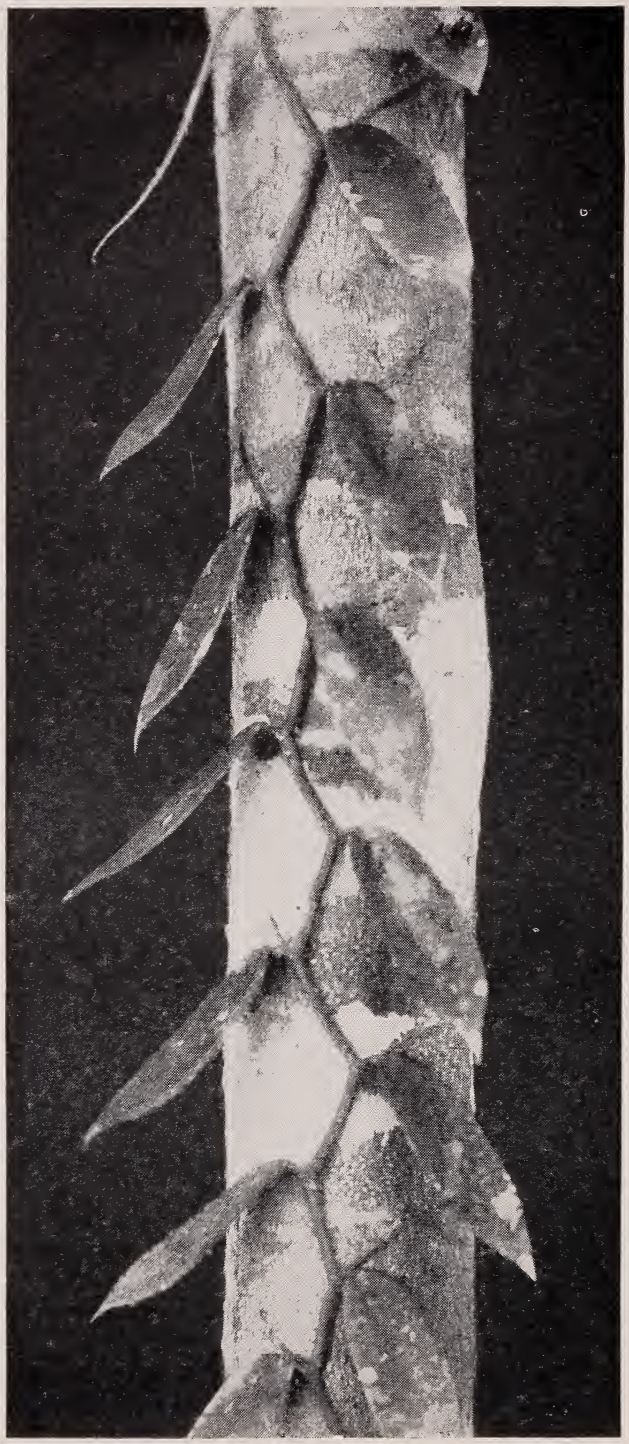

FIGURE 17.—The pomarrosa and mango are undesirable trees either as supports or as shade in the neighborhood of vanilla. A honey dew dropped by a scale insect on these trees accumulates on the vanilla leaves and beans and supports a fungus growth. Such beans require a special cleaning before curing.

Additional plants which have been used in different countries for support trees for vanilla are as follows (*4*) :

Jatropha curcas L. (Physic nut)
Pandanus hornei Balf. f.
Ficus elastica Roxb. (India-rubbertree)
Crescentia cujete L. (Calabash)
Erythrina sp. (Coraltree)
Croton tiglium L. (Croton-oil plant)
Elaeis guineensis Jacq. (African oil-palm)
Bauhinia purpurea L.
Bixa orellana L. (Anatto-tree)
Moringa oleifera Lam (Horseradish-tree)
Pandanus utilis Bory (Common screw-pine)
Dracaena marginata Lam.
Pterocarpus indicus Willd. (Padouk)
Eriobotrya japonica (Thunb.) Lindl. (Loquat)
Dracaena draco L. (Dragon's blood)
Spondias mombin L. (Yellow mombin)
Erythrina variegata Stickm. (Coral-tree)
Gliricidia sepium (Jacq.) Kunth (Madura)
Albizzia lebbeck (Willd.) Benth. (Lebbeck tree)
Casuarina equisetifolia Stickm. (Horse-tail-tree)
Bombax malabaricum DC. (Cotton tree)
Lagerstroemia floribunda Jacq.
Persea americana Mill. (Avocado)
Mangifera indica L. (Mango)
Artocarpus integra (Thunb.) Skeels (Jackfruit)
Manihot esculenta Crantz (Cassava)

It is difficult to recommend a support tree that is ideally suited to Puerto Rico. Dwarf bucare is the most widely used and probably the best until sufficient evidence is available to recommend another tree. If other trees are tried the grower should first consider all desirable characteristics listed above and choose a tree which more nearly answers the needs.

The tall *Inga vera* Willd. (*I. inga* (L.) Britt.) may be used for the principal source of shade and the dwarf bucare under these trees as a support for the vanilla. Dwarf bucare is sensitive to shade from other trees and tends to produce scanty foliage which is desirable under this system of growing vanilla. *I. vera* retains its leaves well during dry periods; also, its relatively tall shade provides favorable conditions of temperature and air circulation near the ground level.

The best vanilla grown at this station is being produced under a lath house constructed from posts and bamboo strips, as shown on the front cover of this circular. Good growth is being obtained where about 50 percent of the roof area is covered with bamboo strips. This intensive system of growing vanilla has many merits and is showing commercial promise.

TERRACING

Since vanilla is planted mostly on sloping land in Puerto Rico, terracing is recommended to prevent soil erosion and also to maintain relatively high and more even soil moisture conditions around the vanilla roots. Some growers construct small individual terraces spaced from 5 to 10 feet apart on the contour line around the slope (see fig. 18). The contour rows are spaced about 8 to 10 feet apart and the terraces are preferably staggered in relation to those above and below. The rows should run east and west, if possible, for reasons discussed later. Periodic master diversion ditches should be provided and spaced 50 to 75 feet apart on the contour on steep land with spacing further apart on gentle slopes. The master diversion ditches accommodate excessive water during heavy rainfall. These ditches have about a 1 percent grade or a drop of 1 foot per 100 feet. They should be kept sodded to prevent soil erosion.

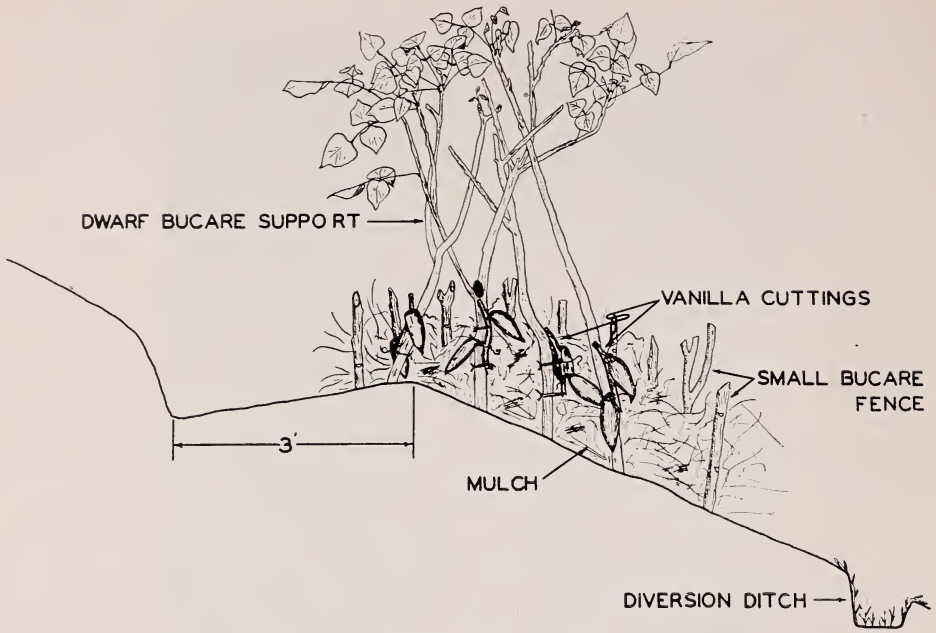

FIGURE 18.—A, Shows terrace construction for a vanilla planting. Dwarf bucare is used for support and for a small mulch-retaining fence around the base of the plants. Four support stumps and four vanilla cuttings are planted to give larger crops at an earlier date. Planting distance is 9 by 9 feet.

B, Recently constructed individual terraces about 3 feet deep by 4 feet wide. Note plantains planted previously to provide cash return and initial shade for the vanilla until the bucare completely develops. Terraces catch and hold additional water during relatively dry periods. Land slope is about 35 percent. Carpet grass is encouraged in the drainage ditches to reduce soil erosion. Mulch may be spread over entire terrace during dry season to conserve moisture. It is not wise to plant vanilla cuttings in depression of terrace due to excessive moisture in rainy season.

In Puerto Rico technical advice and assistance in laying out contour lines and terraces is available through the local Soil Conservation Service. Either the homemade equipment shown in figure 19 or an engineer's level and target are convenient for locating individual terraces at the same level on a contour line. Figure 20 shows implements suggested for use in terracing and planting a vanillery.

Special attention is needed from time to time to see that there are no low areas which contain water for several days after a heavy rain or which tend to keep the area waterlogged. At the beginning of the dry season it may be advisable to place wooden or dirt dams in the terrace channels in order to catch and retain more rainfall in the soil during the infrequent showers.

Planting distance.—It is a mistake to plant the vines so closely that passage between them is difficult. While more vanilla can be pro-

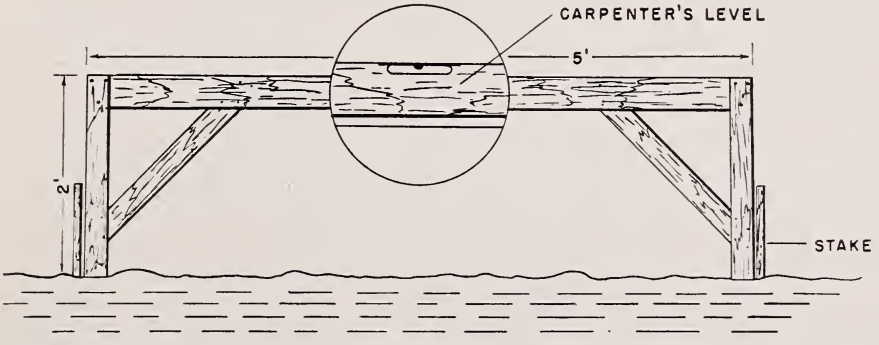

FIGURE 19.—This home-made level is useful on sloping land for locating vanilla terraces at the same level on a contour line. For example, the right stake above is near the border of the new vanillery and indicates the center of a terrace. The level is placed as shown. By holding its right leg stationary the left leg is raised or lowered up or down the slope until the water bubble indicates that equipment is level; the left stake is then driven as shown. Thus, the leveling equipment is moved to the left on a contour level line around the slope as terrace stakes are driven 5 feet apart. Length of bar may be 5 feet, or more, depending upon planting distance.

duced per acre by close planting, this usually results in poor air circulation and increases the likelihood of diseases developing under the more or less continuously moist conditions. Also, wider spacing tends to retard the spread of root and other diseases if they develop on scattered plants. A rectangular planting with plants spaced about 5 to 8 feet apart in the rows and the rows 10 feet apart, is a desirable one. The number of cuttings required per acre for a spacing of 10 by 8 feet is 544.[9] If 4 cuttings are planted in each hill, a system followed by some growers, the total cuttings per acre would be 2,180. Those who use the latter system claim that it induces heavier production at an earlier date.

A 10-foot spacing one way should give ample room for bringing in the mulch and for traffic during the pollination and harvesting. It may be desirable to divide the vanillery into convenient-size blocks of one quarter acre or less with roadways between for mulch carts.

[9] The number of plants required per acre can be determined by multiplying the planting distances (for example, 5 by 10) and dividing the product into 43,560, the number of square feet per acre.

The maximum root extension of vanilla plants examined in the station vanillery was to a distance of about 5 feet from the base of the tree to which the plant was attached. The usual distance is about 2 to 3 feet. In general, the root system is confined to the area covered by the mulch which is within about a 5-foot diameter circle.

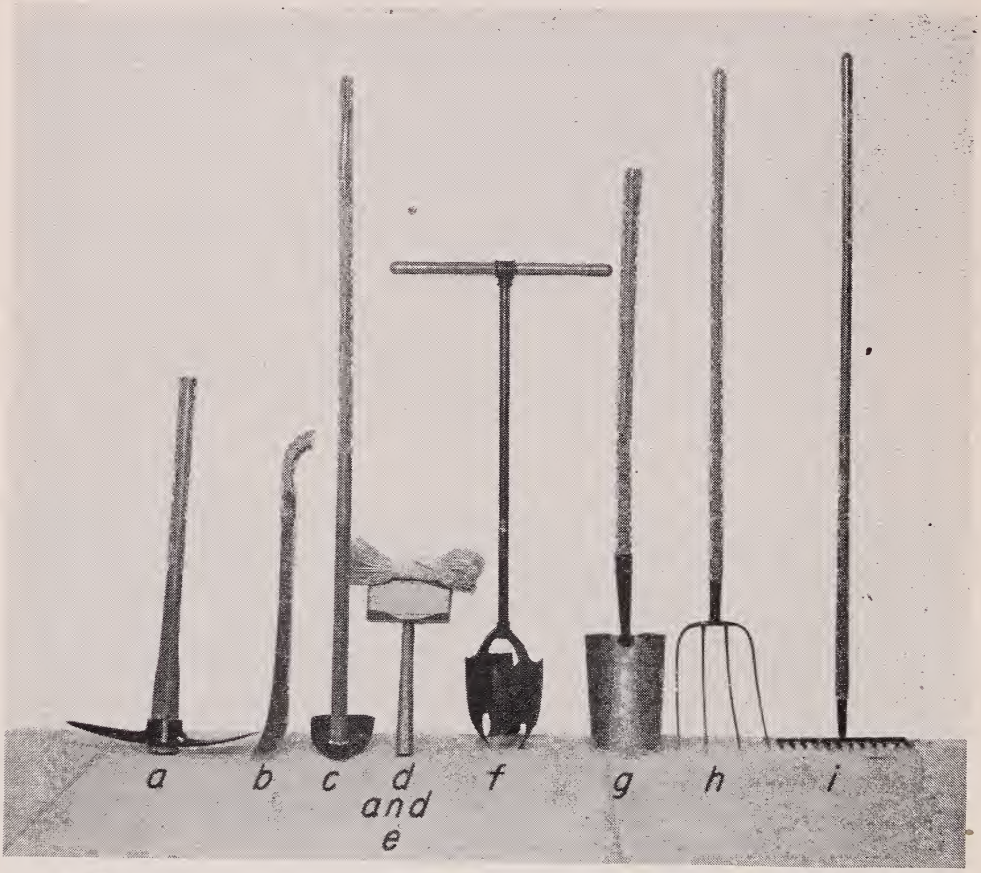

FIGURE 20.—Implements for establishing and maintaining a vanillery. Left to right, *a* Pickax for building terraces in rocky soil and for grubbing roots, *b* machete for obtaining mulch, preparing cuttings, and numerous odd jobs, *c* grubbing hoe for preparing terraces; *d* wooden mallet for driving small bucare cuttings; *e* raffia for tying vanilla vines; *f* post-hole digger for planting support trees and placing a fence around the vanillery; *g shovel* for preparing terraces or planting support trees; *h* fork for handling mulch; and *i* rake for preparing and shaping terraces. The minimum equipment with which the job can be done are machete, grubbing hoe, and shovel.

PROPAGATION

(1) **Cuttings.**—For commercial purposes vanilla is propagated almost entirely by vigorous cuttings of 8 to 12 nodes (fig. 21). Several months can be gained by using large, thick cuttings. The 2- to 4-node cuttings should be used only in an emergency when the larger cuttings are unavailable. After cuttings are removed from the vine, they should be kept in a cool place until planting. All foliage attached should be left. It is not essential that the cuttings be planted immediately, but they should be planted within 2 or 3 weeks.

Cuttings of *Vanilla fragrans* are available from several established

vanilleries in Puerto Rico at a price which has ranged from 1 to 10 cents, depending upon length and thickness. Some growers maintain a number of unpollinated vines in a nearby wooded or coffee area as a source of cutting material.

(2) **Seed.**—Vanilla seeds are dark brown to black in color and only a fraction of the size of a pin head. Under natural conditions, they will germinate in persistently moist places where there is ample decomposing organic matter. Figure 22 shows a vanilla seedling that was one of many that germinated and grew on a rotten wood support in the old curing house at the Federal Experiment Station.

FIGURE 21.—The 8-node cuttings at *a* with large leaves, 5- to 6-inch internodes, and about ⅝-inch girth are the most desirable for planting. Shoot growth from these cuttings will be more vigorous and produce larger vines sooner as compared with the smaller cuttings at *c*. When available, the vigorous 8- and 12-node cuttings are worth the extra initial expense. Small cuttings should be used only in an emergency.

Germination of vanilla seed is of interest only in connection with cross-breeding where an attempt is made to improve varieties. Some cross-breeding with *Vanilla fragrans*, *V. pompona*, and other varieties has been performed at this station in cooperation with Dr. Lewis Knudson of Cornell University in an attempt to obtain seedlings that are resistant to the vanilla root rot organism. The seeds were germinated under controlled conditions in Erlenmeyer flasks containing a special nutrient agar. The system of culture is similar to Knudson's method for growing orchid seedlings for commercial uses (*26*, *pp. 51–53*).

Planting.—A suggested method for planting vanilla cuttings is shown in figure 23. The basal end of the cutting may be buried an inch

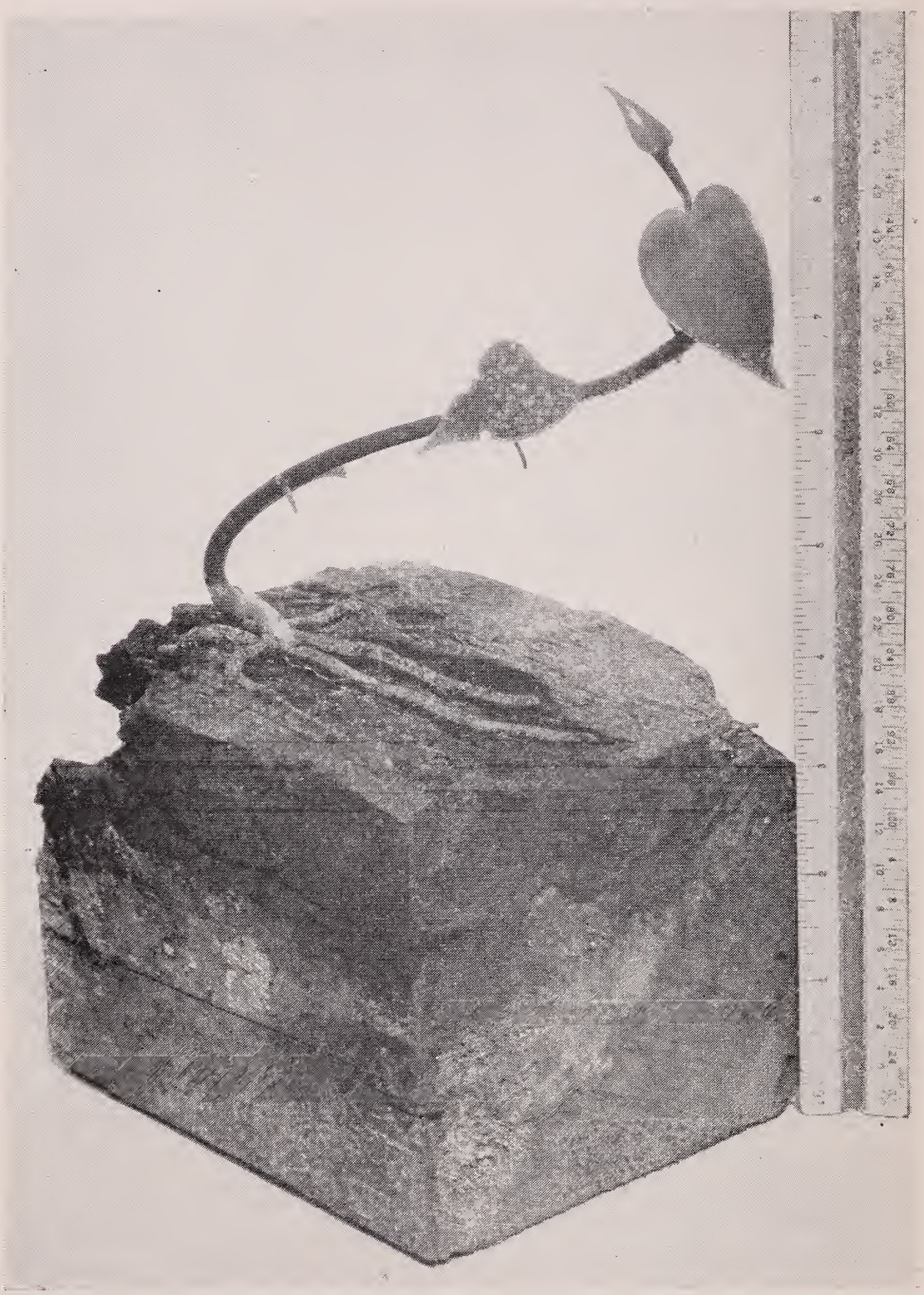

FIGURE 22.—This vanilla plant grew voluntarily from seed which fell on a rotten support in the vanilla curing house at Mayaguez. Percentage germination of vanilla seed under natural conditions is generally very low.

or two in the soil or it may be laid in leaves and in either case covered with 10 to 15 inches or more, of mulch. Observations on Catalina soil (*12*) at Mayaguez show that maximum rooting is obtained when the cuttings are not placed in soil but covered with mulch only. However, the growers in the Morovis area have obtained satisfactory results by covering the lower end of the cutting with soil. The planting practice to be followed probably depends to some extent on the soil and rainfall conditions. The top portion of the cutting is tied snugly to the support tree with raffia, strips from banana leaves, soft jute string, or similar materials. At least half of the cutting should be covered with mulch;

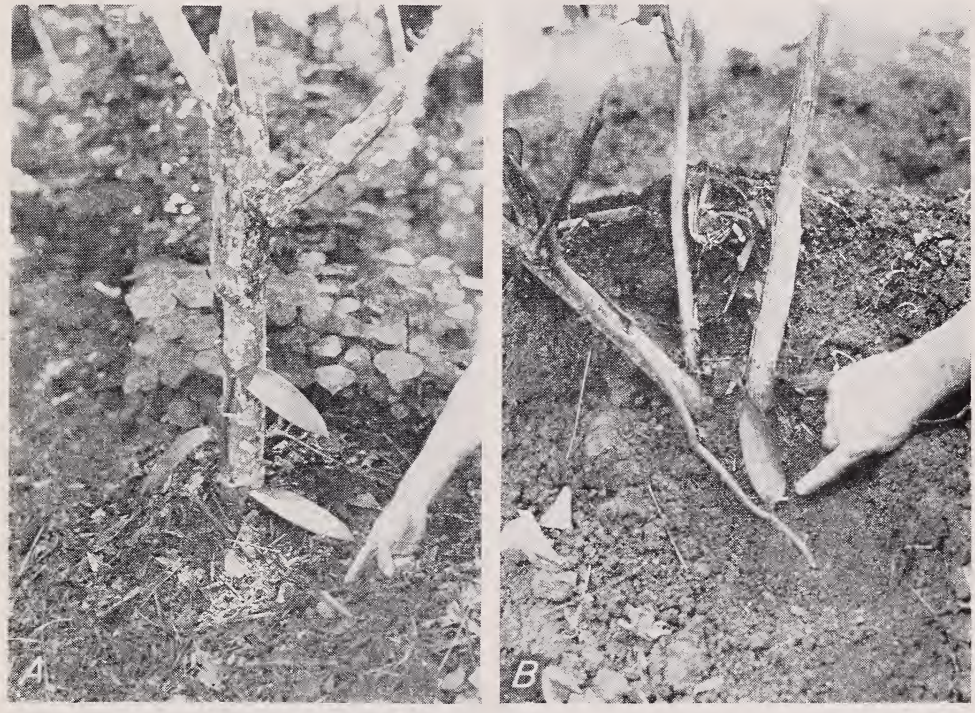

FIGURE 23.—Two systems of planting are used in Puerto Rico. (*A*): The vanilla cutting is planted with about 2 or 3 nodes exposed and the other nodes are covered with 12 to 15 inches of mulch, and the lower end of the cutting is left exposed to reduce likelihood of disease entering through the cut end. (*B*): The lower end of cutting is covered with 2 to 3 inches of soil, on top of which is placed 12 to 15 inches of mulch. Note the small roots appearing 4 weeks after planting. This method of planting is particularly adapted to well-drained soils.

the usual practice at this station is to leave only two or three nodes exposed above the mulch. If the cutting is long, the lower end can be curled loosely on the ground around the base of the support tree. The lower end of the cutting should be left slightly exposed above the ground in order to reduce the likelihood of diseases entering the cut end.

The best time for planting is at the beginning of the rainy season, which in most regions of Puerto Rico is about May or June. However, this varies and in some regions other months may be more desirable.

MULCHING

Vanilla grows best in a 10- to 15-inch mulch of leaves and grass. The mulch is not only a valuable source of nutrients for the vanilla plant, but it helps to maintain a more even moisture supply about the roots during the intermittent dry periods. An abundance of mulch is essential in growing vanilla, especially when the vines are carrying a good crop of beans. Recent results at this station obtained under controlled conditions have indicated that vanilla is able to obtain most, if not all, of its nutrients from the mulch alone and that the quality of the mulch varies. Present indications are that mulch brought from the Morovis area supports a slightly superior growth of vanilla as compared with that obtained from vanilla grown in mulch from Catalina soil near Mayaguez. This may be due to the fact that available nutrients of the soil in either case vary, and that the mulch likewise varies in nutrient quantities.

The grower should make it a regular practice to cut and bring into the vanillery an abundant supply of mulch. Sufficient mulch cannot be grown in the vanillery itself. Therefore, it may be desirable to plant a combined special crop such as tropical kudzu (*Pueraria phaseoloides* Benth.) and a vigorous grass which forms considerable mulch as elephant (*Pennisetum purpureum* Schum.), malojillo (*Panicum purpurescens* Raddi),[10] or guinea (*Panicum maximum* Jacq.). Wherever possible a part of the mulch should consist of legumes since they are high in nitrogen and are often higher in calcium and other important elements than other plants. The amount and quality of mulch obtained from such a crop often can be doubled or tripled by application of 1,000 pounds per acre of a 10–10–5 or similar fertilizer in April. On poor upland soils another application in September may prove worthwhile. Cane mulch is satisfactory provided it is mixed with finer grasses, the general run of weeds, or legumes which deteriorate and furnish nutrients more rapidly to the vanilla. On account of their nitrogen content, legumes alone disintegrate too rapidly leaving the vanilla roots with little or no covering. There is some indication that mulch obtained from the more fertile lowlands or at the base of hills is better than mulch obtained from the less fertile sides and tops of hills.

If mulch supply is a problem during the dry season, quantities of mulch should be stored during the rainy season either in compost piles, or under sheds in order to reduce rapid deterioration. Excess mulch during the rainy season can be piled at the base of vanilla plants to a depth of 2 feet with no harm to the mature plants. The upper shoots of young vanilla plants, however, should protrude above the mulch.

When the support trees are pruned, both the pieces of wood and the leaves can be placed on the mulch to add to the decaying organic matter.

This station and a few vanilla growers follow the practice of building a small fence of living bucare cuttings or strips of bamboo around the base of each plant to help retain the mulch (fig. 18). These fences are an added expense and are not entirely necessary, but they result in an orderly vanillery and prevent workmen and chickens from

[10] Grows best in moist lowlands.

scattering the mulch and exposing the tender vanilla roots to the drying atmosphere. The fence is constructed by driving bamboo strips or living bucare cuttings 1 inch in diameter in the ground about 6 inches apart in a 5-foot diameter circle around the support tree. If the vanilla is growing on an individual terrace, a semicircle bucare or bamboo fence is sufficient for holding the mulch.

A deep mulch *must be maintained* over and around the vanilla roots at the beginning and during the dry season. Pennington's (*15*) motto "Mulch, mulch, mulch, and then add some more mulch," is a timely password for Puerto Rican vanilla growers. Pennington (*15*) recommends a compost pile as a readily available source of nutrients, organic matter, and mulch. The pile consists of alternating layers of weeds, limestone screenings, wood ash (if available), manure, and soil. This pile of convenient length and width should have sufficient size to supply at least 1 cubic foot of compost to each field plant, in addition to freshly cut and dried mulch. If the pile is located in a concrete pit, less nutrients will leach away. The pile should be maintained for at least 6 months and turned once or twice during this time before applying to the field plants.

Narodny (*14*) questions the advisability of heavy mulch for vanilla in Dominica where rainfall is excessive during most of the year (fig. 24). The mulch is said to aggravate the excessive soil moisture situation and to cause root diseases. In all regions in Puerto Rico where vanilla is now grown, however, heavy mulching is highly recommended where soil drainage conditions are satisfactory.

CARE OF THE PLANTATION

Training and pruning the vine.—The vanilla cuttings begin to sprout within 4 to 6 weeks after planting. The vanillery should be visited at least twice a month and preferably once a week to check on the quantity of mulch and to properly train and tie the new shoots. Vanilla shoots grow rapidly, sometimes as much as 2 to 4 feet a month. Some vines in the experimental planting at Mayaguez grew 4 to 6 inches in 24 hours during a favorable period. These vines were about a year old and particularly vigorous.

The new shoots should be tied to the support tree with pieces of local vines, strips of banana leaves, raffia, or soft string. The vanilla vines must be kept within reach in order to facilitate pruning, pollination, harvesting, and general management. If a vine is permitted to grow up a tree, as shown in figure 25, it rarely fruits so long as it is growing upward. Bending of the vine appears to be an important factor in causing it to flower and fruit. One should avoid as much as possible tearing the aerial roots away from the support tree in order to train the vine lower. Vigorous vanilla vines are brittle and heavy and are apt to buckle and snap in two.

Sap from cut vanilla vines causes a skin rash on susceptible people. The use of long sleeves and gloves during the pruning and harvesting periods will help to avoid this difficulty (fig. 26).

When the vanilla shoots reach a height of 5 to 6 feet, they should be tied and permitted to droop. When the shoots reach the ground some growers cover the vine with mulch in order to increase the root system, after which the shoot is trained up again.

FIGURE 24.—Vanilla might be grown without mulch in regions where the annual rainfall is excessive and evenly distributed throughout the season. This practice is considered a risk in Puerto Rico, however, and is not recommended. Photograph showing mulched plant was taken near Ponce, P. R.

FIGURE 25.—Vanilla will climb to the top of tall trees if permitted, but so long as it is growing upward there is little or no flowering or fruiting. Vanilla should be trained and kept within easy reach at a height of about 5 to 6 feet.

One of the leading growers follows the practice of cutting 4 to 6 inches from the growing tip about 6 to 8 months before flowering. Tip removal theoretically results in an accumulation, back of the cut, of carbohydrates manufactured by the leaves. This accumulation of carbohydrates or perhaps other substances seems to be associated with and to induce flower bud formation.

The vines should be kept loose for good aeration and for admittance of light throughout. Matted vines are difficult to manage and they are also more subject to diseases such as mildew. The best time for trimming the plant if it becomes excessively matted is immediately after the fruit has been harvested. Tools for pruning are shown in figure 27.

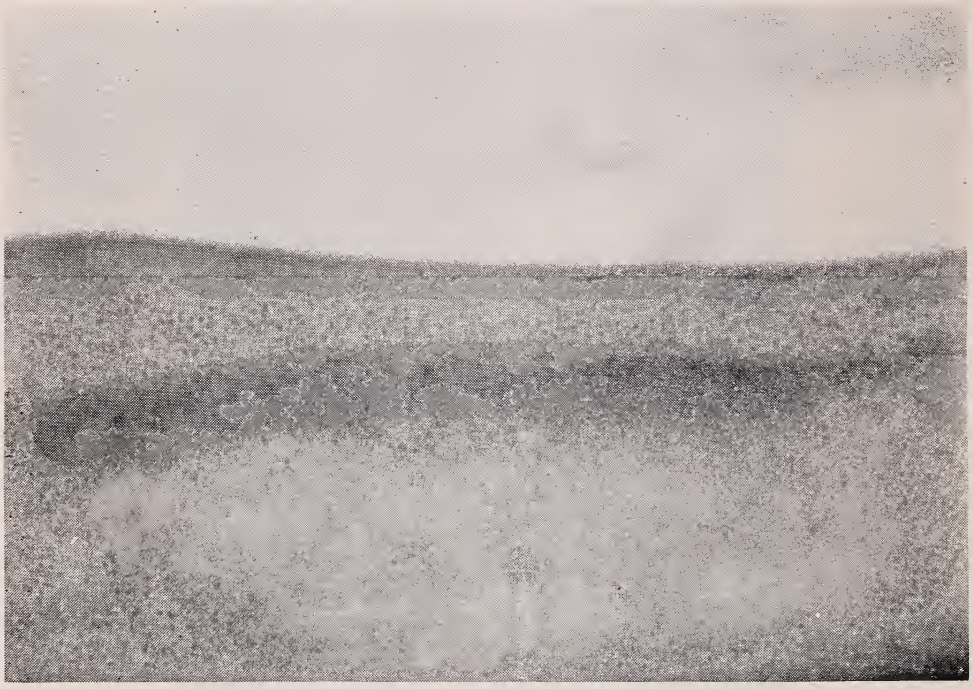

FIGURE 26.—A skin rash similar to that here shown may develop if the sap from the vanilla beans or from the vine comes in contact with the skin of susceptible persons.

In general, vanilla vines in Puerto Rico have been relatively short-lived. They usually begin fruiting the third year after planting and continue fruiting for the next 3 to 5 years before dying. The short life is claimed to be due to the root rot disease, although drought, insufficient mulch, and over-pollination are undoubtedly important factors. Some vanilleries in the neighborhood of Morovis are said to be 11 years of age and are continuing to bear satisfactorily. In Mexico (*10*) the vines begin to bear at the age of about 3 years when a small crop is harvested, and then continue to bear and increase in production for 4 to 5 years. Under average conditions the vines are removed after about 10 years because they have then lost their commerical value. New vanilleries are planted by many growers every 3 years so that a young set of vines will start bearing about the time an old set of vines is removed.

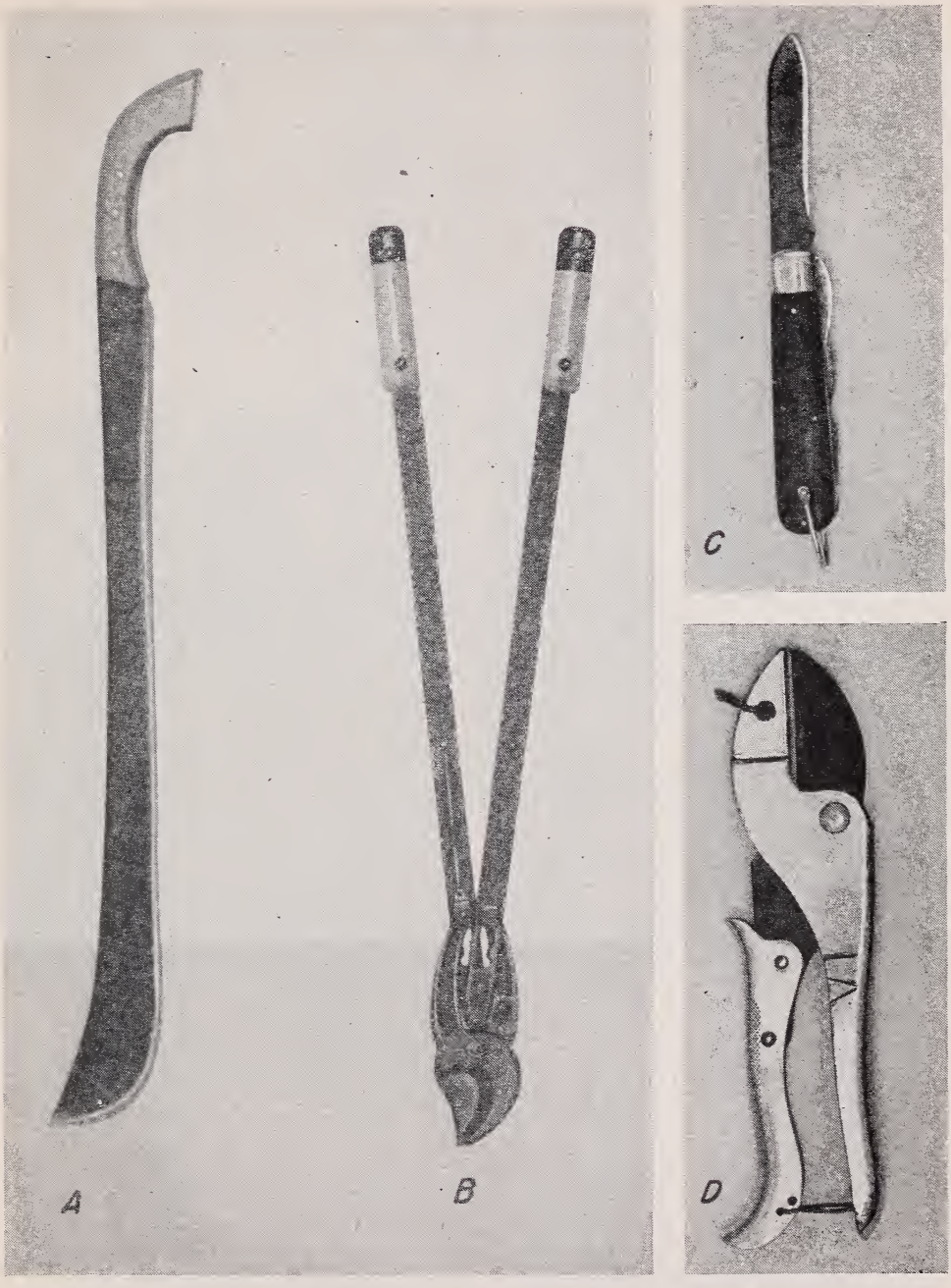

FIGURE 27.—The tools shown in the illustration are suggested for pruning the support tree, the small mulch-retaining fence, and the vanilla vines. The machete (*A*) can be used for pruning support trees, but the 2-foot lopping shears (*B*) give a cleaner cut and with less likelihood of accidental injury to the vanilla. The roll-cut handled shears (*D*) are sometimes preferred to a knife (*C*) for pruning the vanilla and preparing cuttings for planting. The shears are also convenient for pruning the mulch-retaining fence.

PRUNING THE SUPPORT TREE

The amount of sun reaching the vanilla leaves should be carefully regulated. Generally speaking, vanilla can withstand more sunlight during the rainy, high-humidity season than during the low-humidity drought period. Therefore, it is highly important that the support trees maintain their foliage during the dry season. The best time to prune the shade tree would not necessarily correspond with the pruning period for the vanilla. Some growers follow the practice of pruning the dwarf bucare shade trees about 2 to 3 months before the beginning of the dry season (see fig. 28). This reduces the top of the plant in pro-

FIGURE 28.—*A*, A system of pruning dwarf bucare support trees near Morovis is to remove the tops of alternate rows about 2 months before the dry season. Remaining rows furnish some shade for pruned rows; the unpruned rows will be pruned the next year. *B*, Two months after pruning; note the new leaf development on the dwarf bucare and the increased growth of the grass cover crop as a result of more light. Grass will be cut and used for additional mulch.

portion to the roots, induces new shoot growth at a lower level, and enables the tree to retain some of the new foliage during the dry season. The increased light that reaches the ground when this practice is followed stimulates additional cover crop growth that can be cut and used for additional mulch. On dwarf bucare the new foliage usually furnishes adequate shade within 4 to 6 weeks after pruning. Alternate rows can be pruned in alternate years, or, at an interval of 3 or 4 months in one year, preferably during the rainy season in the latter case. Thus, one row partly shades the other while leaves are developing on the pruned row. This system of pruning dwarf bucare has been used only in the Morovis area and is not necessarily adapted to other areas.

Experiments at this station have indicated (*7*) that exposure of vanilla plants to about one-half of full sunlight induces good growth and fruiting (fig. 29). Vanilla leaves show yellowing and sun scald

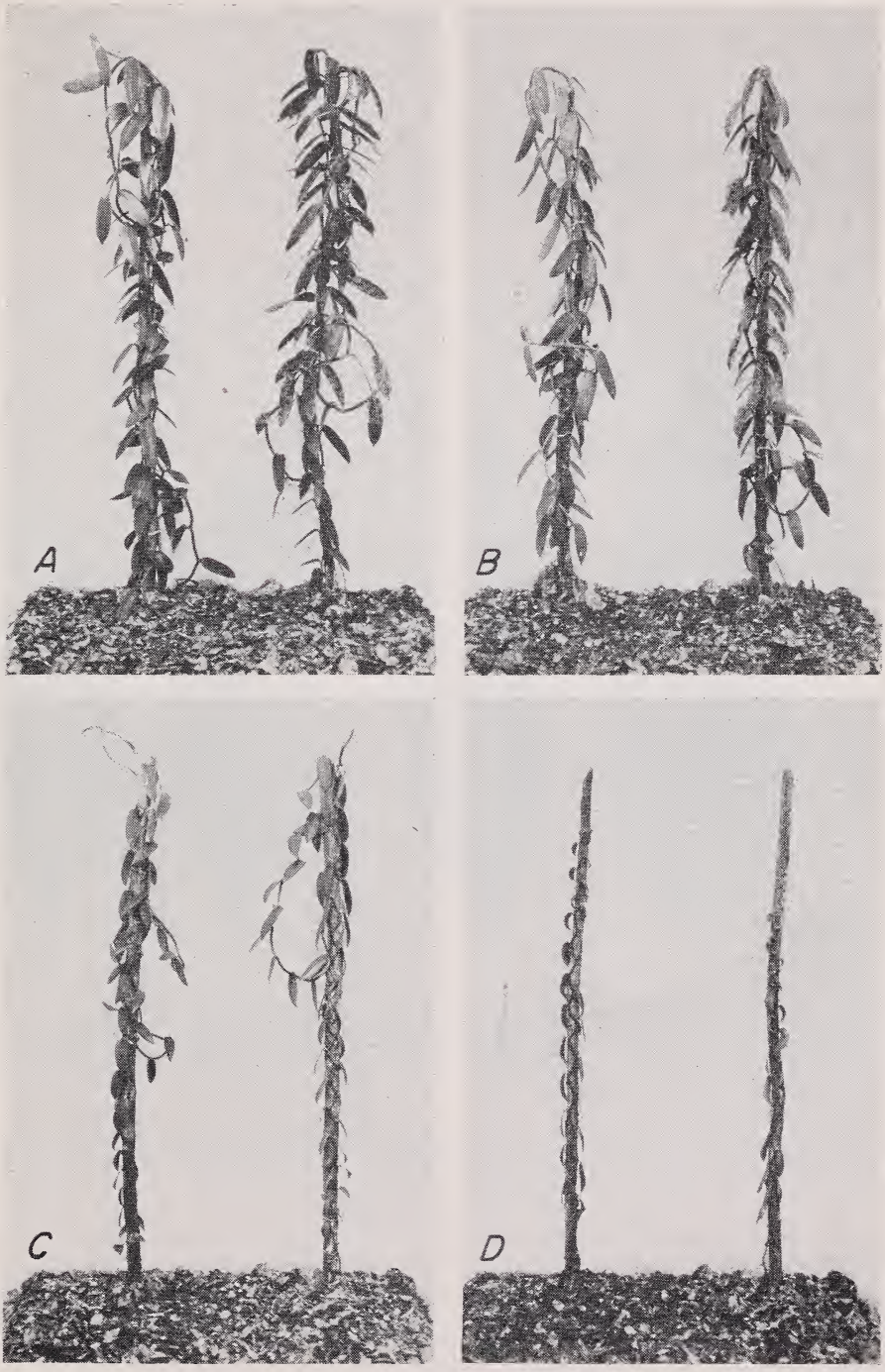

FIGURE 29.—Vanilla requires a rather definite amount of shade for good growth and fruiting under climatic conditions at Mayaguez. The plants were grown in a lath house admitting (*A*) ⅓ of full sunlight, (*B*) ½ of full sunlight, (*C*) ⅔ of full sunlight, and (*D*) full sunlight. Subsequent experiments have indicated that light between ½ and ⅓ full sunlight is most favorable. (After Hernández, (7).

(fig. 30) when subjected to direct sunlight for several hours a day, especially when the humidity is low. From these and other unpublished data obtained recently, it appears that the shade tree should be pruned to admit from 30 to 50 percent of the sun. If the trees are pruned about 3 months preceding the dry season, it may be necessary to perform a certain amount of thinning 7 or 8 months later to maintain an optimum amount of light. The rows of vanilla should run east and west if possible, since this furnishes more shade for pruned rows when the sun is lower to the South during the winter season in Puerto Rico.

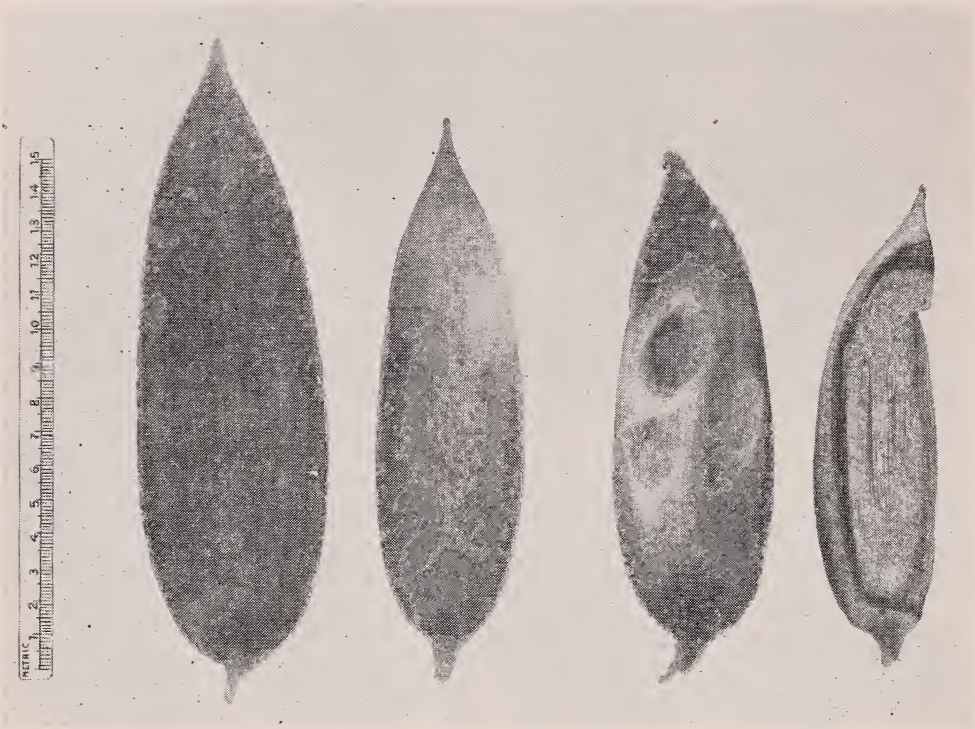

FIGURE 30.—The three leaves at the right show varied degrees of sunburn injury as compared with the normal leaf on the left. Injury is similar to that caused by the feeding of snails. The snails work in moist cool places, whereas sunburn usually occurs on exposed vines.

If a tall shade tree such as *Inga vera* is used in addition to a low support plant, careful attention will be needed in pruning both the plants to admit sufficient light to the vanilla.

It is highly important not to permit the vanilla to become heavily shaded. Under heavy shade the stems are thin, leaves small, and the fruiting and flowering mediocre. Under too much sunlight, the leaves not only scald and turn yellow, but the plant becomes weak during drought periods and is more susceptible to the root rot disease.

In pruning, extreme care must be taken to prevent damage and breakage of vanilla vines. Close supervision of the pruning operation is necessary.

WEEDING

Because of shade in the vanillery the number of different weeds and the amount of growth made by them is ordinarily small. A limited amount of weed growth is desirable to prevent soil erosion and to provide mulch for the vanilla. However, weeds should not be permitted to grow taller than knee high because they reduce air circulation and compete with the vanilla for water during periods of low rainfall. Weeds should be kept mowed during the dry season.

BLOSSOMING AND FRUITING

At Mayaguez the first blossoms appear on vanilla in January; flowering reaches a peak in March, gradually decreasing until June. A given plant usually blossoms over a period ranging from less than 1 month to 2 months. In a study made by McClelland (*12*) the average cluster of flowers contained about 14 blossoms opening over a period of 24.5 days. During this period blossoms were present for 13.6 days and during the other 10.9 days there were no blossoms. Only rarely do as many as three blossoms on a single cluster open on the same day, and usually only one opens in a day. There is a period of approximately 2 months between the time that the first inflorescence bud appears and the first blossom emerges. On mature vines, flowers have appeared in the spring on growth made as late as the preceding October.

Flower Description.—McClelland (*12*) gives the following description of a flower of *Vanilla fragrans* (Salisb.) Ames.

> The flowers are borne in a spike or raceme [see fig. 31], sometimes branching and forming a panicle. The inflorescence is centripetal and usually axillary, but occasionally it terminates a long stem. The waxen, pale-green blossom is borne at the apex of the ovary, which is 4 to 5½ cm. long at blossoming. This is subtended by an ovate bract about 5 mm. long and 4 mm. broad at the base. The five spreading segments of the perianth are rather similar, 6 to 6½ cm. long, 1.3 to 1.5 cm. broad, unsymmetrical, elliptical-spatulate, and not much recurved. The midrib at the back of the two petals is about 3 mm. shorter than the petal, its tip not adnate for 1 to 2 mm. and recurved. The trumpet-shaped labellum, or lip, which is united with the column, is about 5 cm. long and 1.5 cm. in diameter. The disk of the lip is yellowish-green and verrucose, with a central crest or tuft facing the essential organs. The margin of the lip is unevenly dentate. The column is about 5 cm. long.

An abnormal flower cluster of *Vanilla fragrans* is shown in figure 32, *A*. These are occasionally seen and appear to be the result of a disease known as "blossom blast" as described by Kevorkian (*8*). Another unusual situation is shown in figure 32, *B*.

Pollination.—In Mexico where vanilla is native, it is said (*10*) that small bees of the genus *Melipona* and humming birds are responsible for a certain amount of natural pollination, but, as far as the literature reveals, this point has never been carefully checked. On the basis of observations at this station, natural pollination in Puerto Rico is probably not more than 1 percent. It is, therefore, necessary to pollinate the flowers by hand in order to obtain commercial quantities of beans. The procedure involved is simple and can be easily performed with a little training.

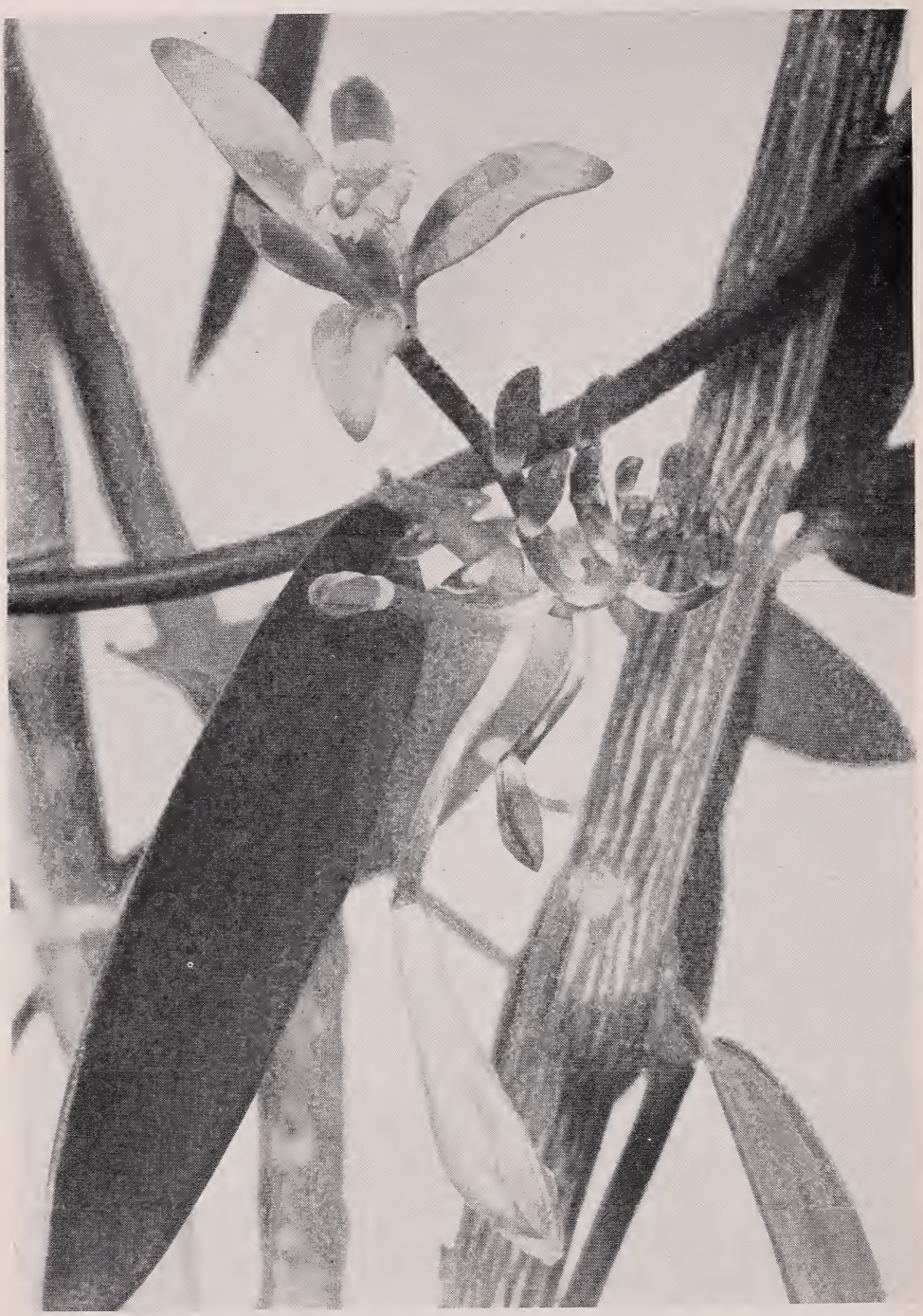

FIGURE 31.—There are from 15 to 20 or more greenish yellow, rather inconspicuous flowers in an axillary raceme of *Vanilla fragrans*. Each vanilla flower remains open for about a day and may drop within 1 day if unpollinated. The support tree shown is dwarf bucare (*Erythrina berteroana* Urban).

Charles Moran of Liege was probably the first man to obtain large crops of beans by hand pollination in 1836 (*21*). In 1838 Moran's technique was successfully repeated by Newmann of the Museum d'Histoire Naturelle in Paris (*21*). In 1841 Edmund Albius, a former slave in Réunion, developed a practical method for artificial pollination which is being used today in commercial vanilleries.

The reason hand pollination is necessary is because there is a fleshy flap known as the rostellum or lip, which lies between the male and female organs, as shown in figure 33. It is necessary to lift this flap

FIGURE 32.—*A*, An abnormal flower cluster of *Vanilla fragrans* (Salisb.) Ames. Note proliferation of flower buds from the basal bracts of the peduncle. This was found to be associated with the diseased condition known as "blossom blast" and fruit rot. *B*, This vanilla shoot is unusual in that it is bearing single beans at two nodes. Late and incomplete flower formation was probably caused by injury to the shoot tip.

and press the anther or male organ, as shown in figures 34 to 37, against the lower stigmatic surface of the female organ. Thus, the pollen grains from the anther are smeared upon the sticky surface of the pistil, where they germinate and send pollen tubes into the pistil until they reach the female eggs and fertilization takes place, forming the seed. If fertilization takes place within a matter of hours, the ovary will remain a part of the raceme and begin to enlarge into a pod. If fertilization does not take place, the flower will wilt and drop within 1 to 2 days. The bean increases in size rapidly after pollination, as

shown by figure 38. It attains full size within about 6 weeks, which readily explains how exhaustive is the fruiting process.

From one to three flowers on a raceme open each day starting early in the morning and closing in the afternoon of the same day. Therefore, it is necessary and advisable to pollinate during the morning period starting as early as feasible. The vanillery should be inspected once a day during the peak of the blossing season and on alternate days or less often at other times, depending upon the number of flowers opening and the need for additional beans to fill the quota of each vine. The flowers which should receive first choice in pollination in a

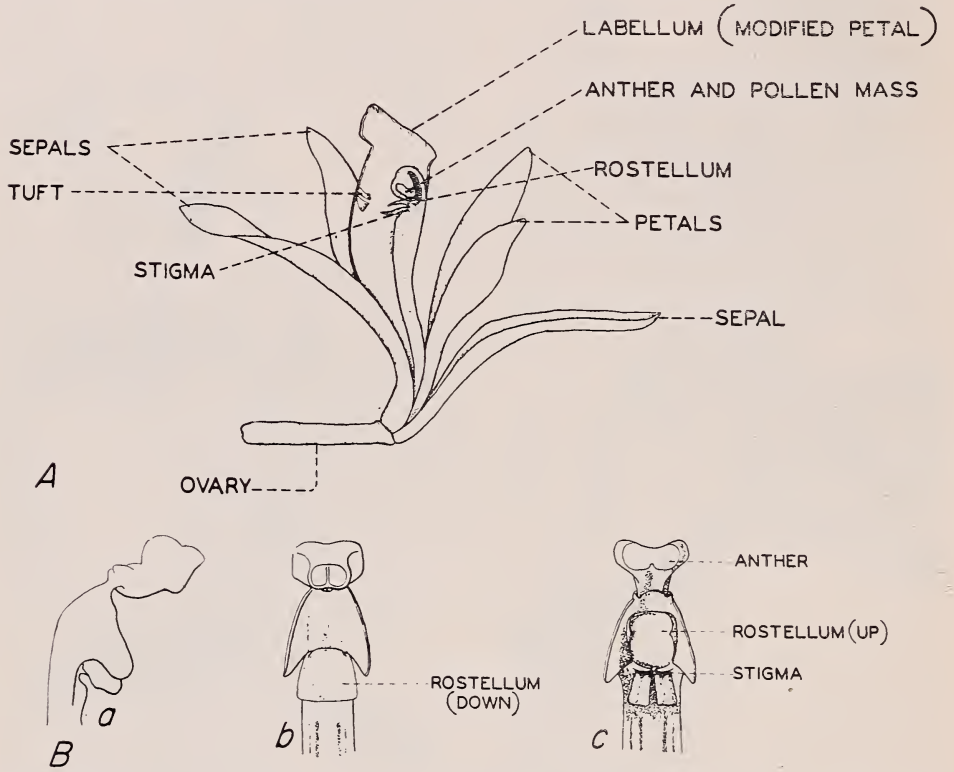

FIGURE 33.—*A*, Parts of the vanilla flower. The anther, rostellum, and stigma are of chief interest in hand pollination. At *B*, *b*, the end of the column is shown with the rostellum normally down. In hand pollination this flap or rostellum must be mechanically lifted, as at *B*, *c*. in order that the male organ (anther) can be pressed against the female organ (stigma). A side view of the column is shown at *B*, *a*.

raceme are those which hang downward. Beans developing from these lower flowers tend to form straight beans, whereas beans developing from flowers on the upper side of a raceme are often crooked and bring less money on the market. Also, crooked beans are difficult to bundle, and may give the bundles a straggly appearance.

Women and children are well suited to pollination work. Working steadily, the average person can pollinate between 1,000 and 1,500 blossoms a day, or about 4 a minute, on the basis of a 5- to 7-hour day. Pollination may be continued until late in the afternoon, although the flowers begin to close in early afternoon. Experiments by McClelland (*12*) have shown that flowers will set fruit satisfactorily when pol-

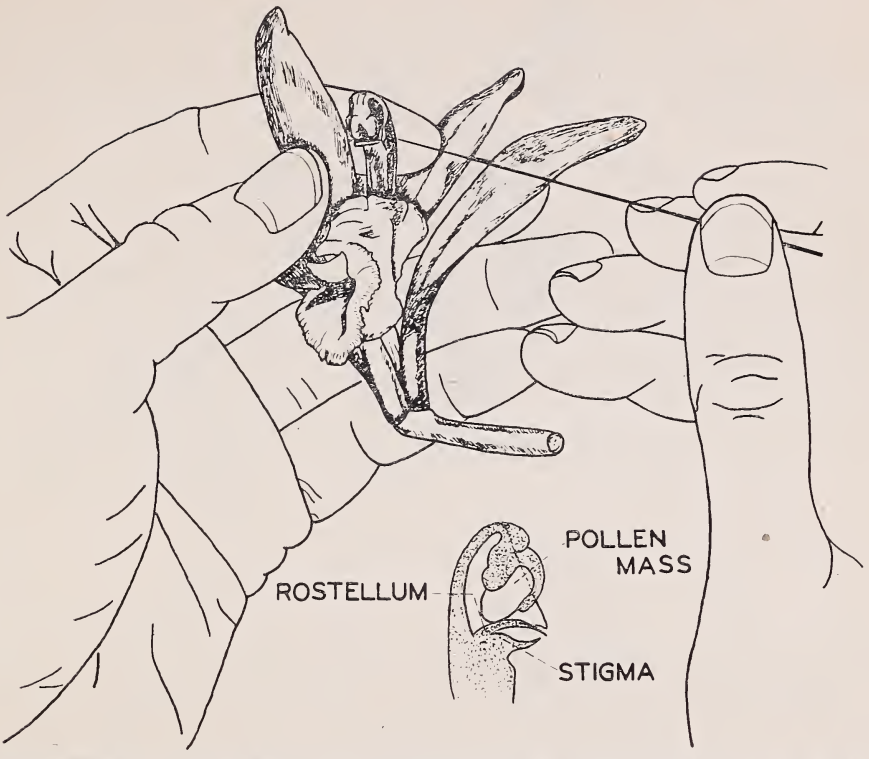

FIGURE 34.—The four steps in hand pollination of vanilla flowers are shown in this and accompanying figures. *First*, the labellum, or, modified petal, is twisted down leaving the column exposed. The flower is held in the left hand and a bamboo stick or similar object is manipulated with the right hand.

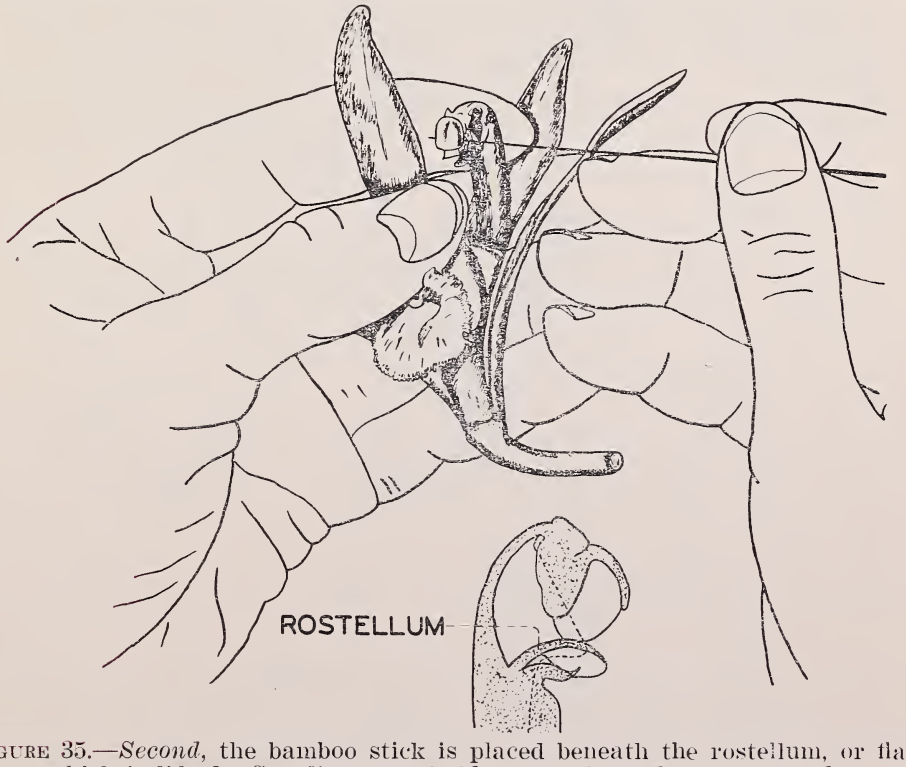

FIGURE 35.—*Second*, the bamboo stick is placed beneath the rostellum, or flap, which is lifted. See diagram of side view of column below hands.

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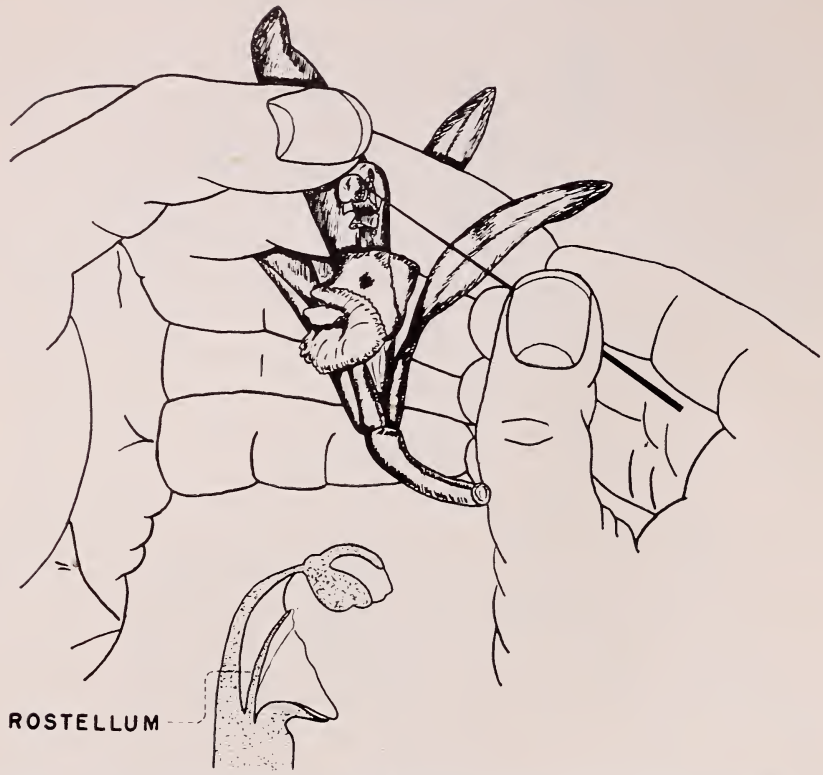

FIGURE 36.—*Third*, the rostellum is pushed to the back, while the left thumb is brought into position for the next step.

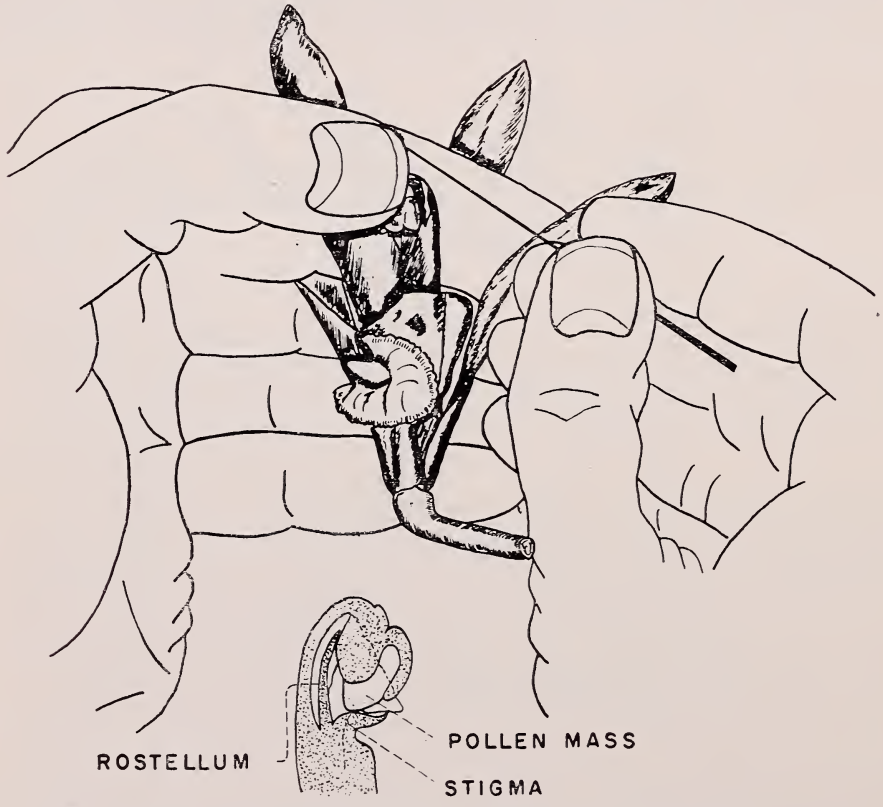

FIGURE 37.—*Fourth*, with the rostellum up the stamen is pressed downward with the left thumb until it smears the pollen upon the stigma below.

linated in the late afternoon after a rain, probably because the flowers usually rest horizontal or downward and the essential organs are protected from rain by the labellum. McClelland also showed that beans developing from the first flowers to open in a cluster are not significantly better than those developing from the later opening flowers.

The workmen must be cautioned against pollinating too many flowers on a vine. There seems to be an inherent desire on the part of laborers in general to pollinate every flower in order to give each one an opportunity to reproduce. It cannot be stressed too emphatically that the rapid development of a large crop of beans on a vine creates an excessive drain on the food materials stored in the vine. With over-pollination the vine soon becomes weakened and is then highly susceptible to the root-rot disease and drought. Also, if too many flowers are pollinated the resulting beans will be smaller in size and weight (*26*, *9*). Small beans require more labor to harvest, cure,

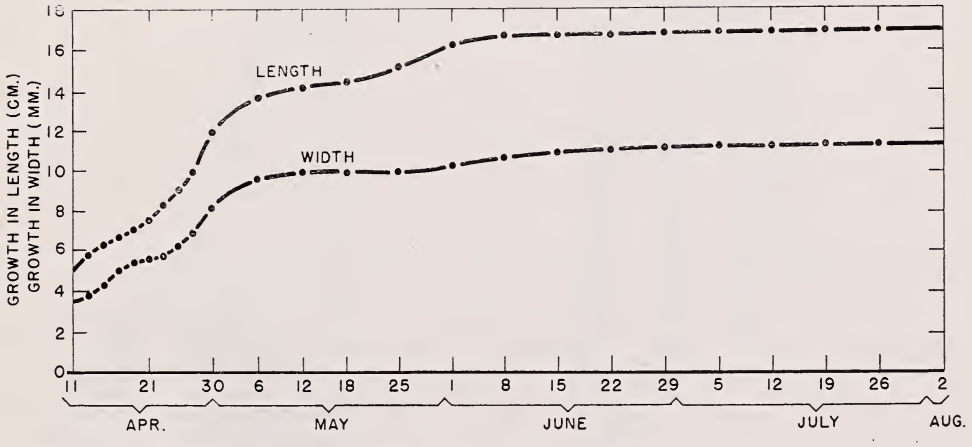

FIGURE 38.—The growth in length and width of a vanilla bean is almost completed within 6 weeks after pollination. This indicates the heavy drain on reserves of the vanilla vines shortly after fruit is set.

and pack and have a lower market value than the larger beans. Also, it requires more labor to pollinate excess flowers.

In Puerto Rico the average mature vine contains between 10 and 20 flower clusters. The number of flowers in each cluster varies between 12 and 24. McClelland (*12*) recommends leaving about 4 to 6 pods per cluster (fig. 39) or about 100 to 150 pods for an average 4- or 5-year-old plant. Under his pollination conditions the average pod was about 6½ inches in length and weighed 13 gm. Thus, a single plant could be expected under average conditions to produce about 3 pounds of green beans, or a little more than ½ pound of cured beans. The size of different plants varies considerably, however, and a small 4-year plant (fig. 24) might be allowed to develop only 6 to 12 beans while extra large plants (fig. 13) could support as many as 300 or more beans, with plants of intermediate vigor bearing between 100 to 150 beans.

Table 6 gives the number of green beans required to make a pound, depending upon the length of the pod. For example, it requires about 112 beans 4 inches long to make a pound and only 16 beans 8½ inches

FIGURE 39.—About 5 or 7 flowers should be pollinated on each cluster. This allows for the possibility of some flowers abscissing and others developing into "runts" (left bean) which are removed as soon as it is evident that they will make little or no additional growth. In order to prevent overpollination and short life of the vine, therefore, it is suggested that each cluster should mature from 3 to 4 good beans.

long to make a pound. Thus, it can be seen that considerably more time is required for pollinating, picking, and handling the smaller beans. The large beans are also said to produce an extract slightly superior to that produced from small beans (*27*).

TABLE 6.—*Comparative weight of green vanilla pods of different lengths* [1]

Length of pods	Average weight per pod	Number of pods per pound	Length of pods	Average weight per pod	Number of pods per pound
Inches	*Grams*		*Inches*	*Grams*	
4	4. 04	112	6½	13. 92	32. 50
4¼	4. 64	97. 75	6¾	15. 64	29. 00
4½	5. 56	81. 25	7	16. 12	26. 50
4¾	6. 28	72. 50	7¼	18. 76	24. 25
5	7. 24	62. 75	7½	20. 64	22. 00
5¼	8. 44	53. 75	7¾	22. 44	20. 25
5½	8. 92	49. 75	8	24. 52	18. 50
5¾	10. 20	44. 60	8¼	27. 24	16. 75
6	11. 32	40. 00	8½	28. 16	16. 00
6¼	12. 56	35. 70			

[1] From a table by McClelland (*12*). His weight figures for cured beans were multiplied by 4, assuming a 4:1 drying ratio. His number of cured pods per pound were divided by 4 to obtain the number of green pods per pound as shown above.

When a plant has been forced to produce an excessively large number of pods in a given crop, not only are the subsequent crops small, but the vine begins to assume a dilapidated appearance and either soon dies or requires several more or less unproductive years to regain its vigor. It is probably fortunate that artificial pollination is required with vanilla. The man performing the pollination is then in a position to govern the size of the crop that a vine will carry. This is not true with most fruiting plants which in some years bloom profusely and set excessive crops of fruit that necessitate considerable hand labor in thinning 1 to 2 months after flowering. With vanilla little or no hand labor for thinning is required if only slightly more than the needed beans are pollinated (some pollinated flowers may drop). Under these conditions, it is not necessary for the vanilla plant to waste energy in developing fruits that later will be thinned off.

Before sending a group of people into a vanillery to pollinate, they should be carefully instructed collectively or individually regarding the principles underlying pollination, why it is necessary, and how it is done. The manager or foreman might point out relatively low vigor, medium vigor, and vigorous plants within a given age, stating the number of pods which each plant should be allowed to develop. For either a low vigor or young vine perhaps one dozen beans or less are satisfactory; for a medium vigorous vine, 50 to 100 beans; and for a vigorous vine, about 175 beans. As stated earlier an excessively large plant might be allowed to carry 300 or more beans, but it is doubtful if this is good practice for any vine from the standpoint of its longevity.

Those performing the pollination operation will need to exercise good judgment regarding the number of beans a given plant should be allowed to produce. This comes only with experience and study. Laborers should be mixed so that experienced pollinators are working with and checking the work of inexperienced pollinators.

A vine should *not* be allowed to develop and open more flowers than necessary. Flowering, as well as fruiting, creates a drain upon the food reserves of a plant. In spite of careful pollination, a small percentage, or 5 to 15 percent, of the pollinated flowers often drop before maturity. When slightly more than the desired number of beans has been attained for a given vine it is well to remove with a knife or blunt scissors the remaining unfolded buds from the inflorescences.

In conclusion, it might be stated that from a scientific standpoint the number of beans a plant is allowed to carry should be determined by the amount and vigor of leaf surface on the plant. For example, each bean theoretically should be supported by a definite area of leaf surface, inasmuch as the leaves are the organs which furnish synthesized food materials for bean development. Such a relationship between leaves and fruit has been established for apples (*6*) and many other temperate fruits, but as yet no research of this character has been reported for vanilla. Unquestionably, the vanilla grower should consider the extent and vigor of the foliage in regulating the individual crop for a plant. It would not seem wise to pollinate a plant heavily because it is flowering heavily. It is common knowledge in plant physiology (*6*) that a plant often flowers heavily because it has been weakened by some adverse environmental condition. Certainly, if such an incipiently weak plant is forced to mature a heavy crop of beans, it will be literally exhausted by the end of the season. Such a condition quickly leads to the death of the vanilla plant. It is poor business to spend money, labor, and 3 years establishing a vanillery, and then kill it in 2 or 3 years by excessive fruiting.

HARVESTING

The harvesting season in Puerto Rico usually begins in September and continues to the following June, the bulk of the crop being harvested in December to March, inclusive, as shown in table 7.

The beginning and the end of the ripening season may vary a month or two, depending upon elevation and other environmental factors. From the time of blossoming, it requires from 7 to 9 months for the beans to reach proper picking maturity. The best sign of approaching maturity is the slight yellowing of the apex or lower end of the bean, while the middle and base or upper end is still green. Plate 1 shows the various degrees of maturity of beans and the proper stage at which they should be picked. If the pods are allowed to become too ripe, they split into unequal halves and must be placed in the "cuts" class, bringing a lower market return. The beans usually become oily on the surface immediately before the apex begins to yellow.

Figure 40 shows a suggested procedure for picking beans. A pod which has reached proper maturity usually can be removed unbroken by a sidewise pressure of the thumb against the base of the pod and the forefinger. The pod is apt to break if the pressure is not applied directly at its base, or if the pod is twisted in the process. If a small piece of stock remains with the harvested pod, it should be removed with a short knife, care being taken not to cut the base of the pod.

PLATE 1.—Beans must be picked at the proper time in order to secure the highest aroma and quality during curing. The bean on the left is too green; the second and third beans to the right are of proper maturity, with the tips beginning to turn yellow; the fourth and fifth beans on the right are overmature, both showing splitting, and the one on the right beginning to turn black. The latter two beans will be sold as "cuts" at reduced profit.

TABLE 7.—*Pounds of fresh vanilla beans received by month in 1943–44 and 1944–45 at the cooperative curing plant, Castañer, P. R.*

Month	1943–44	1944–45
	Pounds	*Pounds*
September	2. 69	19. 25
October	84. 05	212. 75
November	1, 479. 52	1, 260. 23
December	3, 232. 66	4, 165. 36
January	5, 502. 95	8, 706. 56
February	7, 168. 97	6, 323. 90
March	3, 839. 55	5, 166. 50
April	489. 99	1, 969. 74
May	19. 75	1, 213. 18
June		30. 50

In some countries such as Dominica (*14*), and Mexico (*10*), where vanilla growing is a relatively big business, the stealing of beans a month or two in advance of maturity has become a serious problem, especially when the market for vanilla is good. During World War II (*10*) the loss of beans in Mexico through theft amounted to about 1 pound in every thousand pounds of beans harvested. In the 1940–41 crop which was bringing high prices, it is reported that there was a 20-percent loss of the cured vanilla crop because of premature harvest by the growers themselves for fear of thievery. Beans harvested when green are of poor quality and some of them may be almost worthless. In Dominica, Narodny (*14*) uses a small implement made from broken razor blades mounted in a hardwood stick for branding the beans. Different growers have different symbols. The brand is relatively small and does not harm the market value of the beans. The buyer is acquainted with the brands of the various growers and tries to buy only beans bearing the respective grower's brand. When prices are good, however, in spite of all measures, including the "shot-

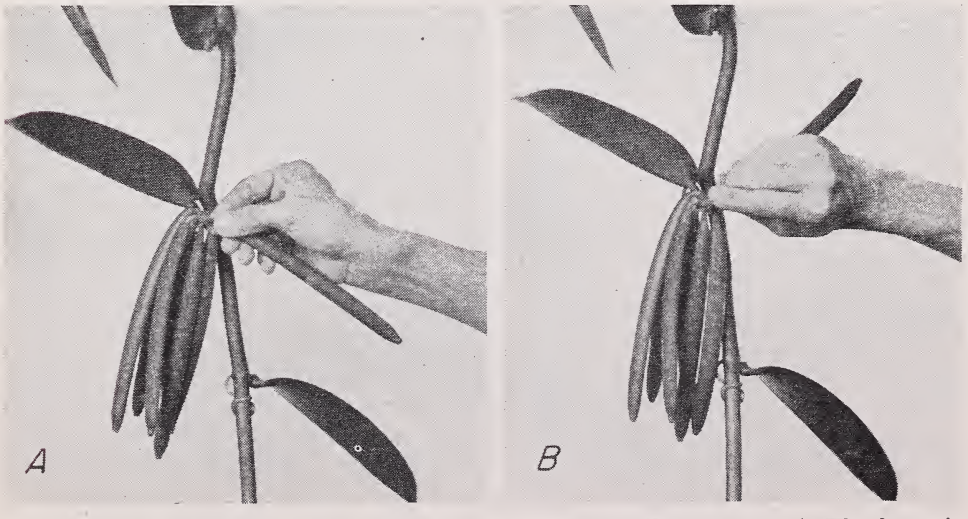

FIGURE 40.—A suggested procedure for harvesting vanilla beans. *A*, The bean is clasped near its base with the thumb and forefinger. *B*, The bean is lifted and slightly twisted while pressure is exerted against it with the thumb.

gun guard," there is a certain amount of stealing and black marketing. Relatively little difficulty in stealing has been encountered in Puerto Rico, probably due to the fact that the industry is still small.

In July 1941, the Mexican Government attempted to curb stealing by issuing a decree which fixed a seasonal date line before which the cutting and curing of vanilla is prohibited. The decree also limits the exportation of green or cured vanilla to the period from January 15 to July 15 of each year. Dominica recently took similar steps. The uniformity of product from Madagascar and neighboring islands with respect to maturity and quality is due in a large part to government laws which regulate time of picking.

INSECTS AND OTHER PESTS

Damage to vanilla plants caused by insects is of limited importance in Puerto Rico. In a survey made by Plank in 1938 (*19 pp. 118–121*) a number of insects were found causing only minor injuries. Insects noted were: A black weevil (*Diorymerellus* sp.) causing injury to the tip of vanilla shoots as shown in figure 41; a small leaf tyer (*Platynota rostrana* Walker); an aphis (*Cerataphis lataniae* (Boisd.)); an earwig (*Doru* sp.); and a wooly bear caterpillar (*Ecpantheria icasia Cramer*, fig. 42). In addition, there is a tip borer (*Terastia meticulosalis* (Guenee)) which causes limited injury and growth restriction to the commonly used bucare support tree (*19, p. 121*). With exception of the tip borer, other insects listed above, if important, can be controlled by the usual spraying materials and methods employed for sucking and chewing insects.

Among the most troublesome pests in Puerto Rico are the snail (*Thelidomus lima* Fér.) and slug (*Veronicalla kraussii* Ferussac). Damage by these pests consists of removal of the outer portions or entire sections of buds, leaves, shoots, and immature beans. They cause most damage during the warm, damp summer weather. The abundant mulch material furnishes an ideal harboring place for the slugs and snails away from the direct sunlight. Slugs (fig. 43) feed largely at night, but the snails (fig. 44) work more or less continuously. As soon as damage is noted, a poison bait should be prepared and distributed as shown in figures 45 and 43. A metaldehyde bait mixture has been used effectively at this station consisting of ½ pound of metaldehyde (obtainable at drug stores or chemical supply houses), 16 pounds corn meal or bran, ½ pound calcium arsenate, 16 pounds chopped grapefruit, and enough water to make a moist mixture. Two or three ¾-inch balls of the bait are distributed at the base of each vine.

Some growers consider chickens their worst pest. Chickens can do considerable damage to vanilla in a short time by scratching away the mulch, tearing the roots apart, and exposing them to the drying atmosphere (fig. 46). This undoubtedly has a stunting effect on the vines and consequently reduces production. A wire fence erected around the vanillery is an effective measure in excluding the majority of the chickens; it is also valuable in keeping out malicious people.

Lizards may reduce the grade of the beans by scratching the epidermal layers (fig. 47) and causing corky streaks to develop. This injury has not been considered of sufficient importance in Puerto Rico to necessitate control methods.

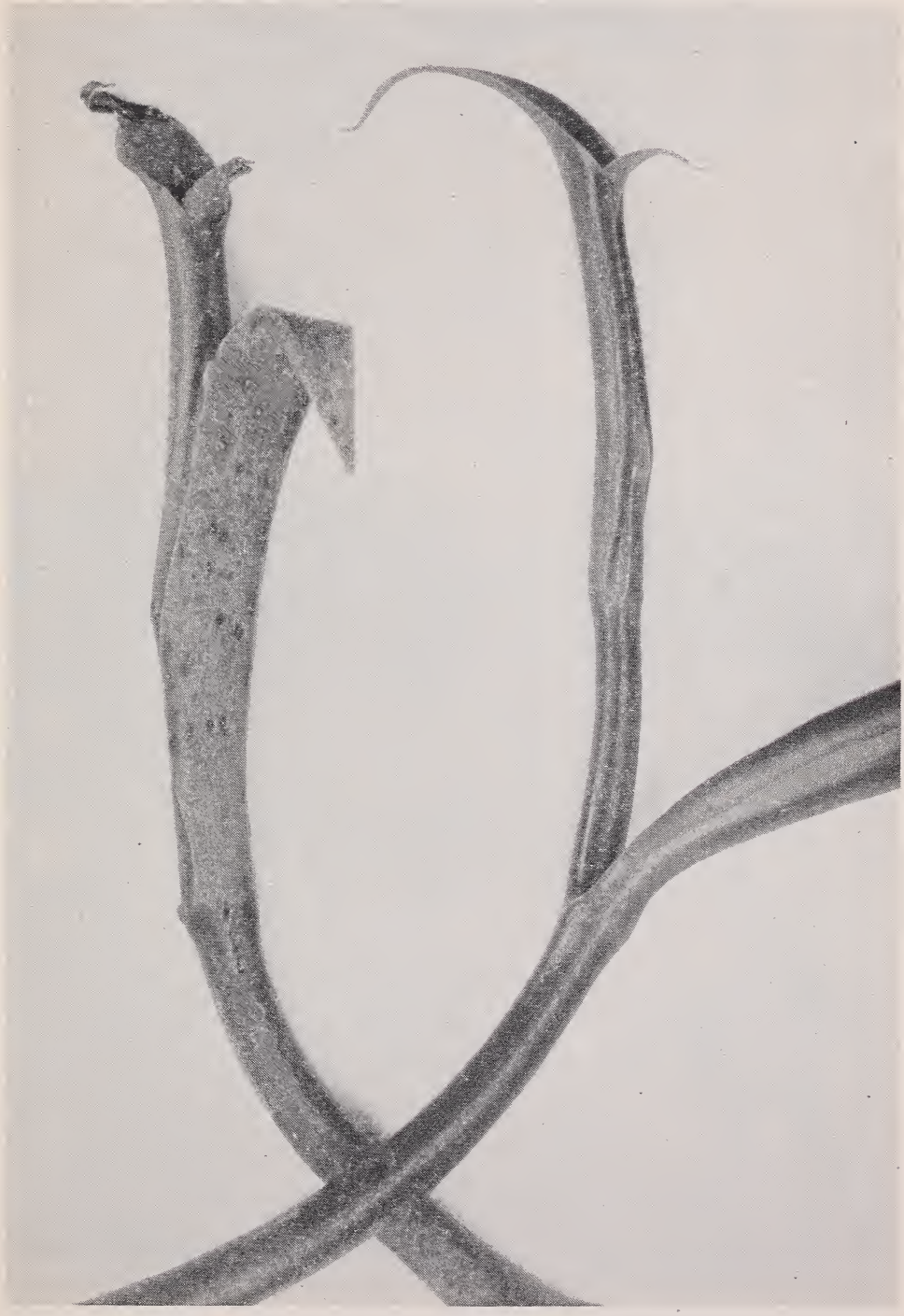

FIGURE 41.—Terminal portion of this vanilla vine was injured by small black weevils (*Diorymerellus* sp. near *obliteratus* Champ.). The injured shoot at the left shows sunken areas with elliptical water-soaked margins, characteristic of the feeding punctures. Tip of an uninjured shoot is shown at the right.

FIGURE 42.—The wooly bear caterpillar (*Ecpantheria icasia* Cramer) may eat sections of the vanilla beans and stems. The injury resembles that caused by slugs as shown in figure 43.

FIGURE 43.—*A*, Slugs can be disastrous in a vanillery. Feeding such as this at the base of the vine seriously weakens or kills the vine. Poison bait is prepared as demonstrated in figure 45 and distributed in about four pinches at the base of each vanilla vine as shown in figure 43, *B*. *B*, Dead and paralyzed slugs are shown on the mulch.

FIGURE 44.—Snails (*Thelidomus lima* Fér.) are a common pest of vanilla in Puerto Rico. Two sizes of the same species are shown (top). The larger specimen, 1¾ inches in diameter (bottom), came from Morovis. Damage caused by a snail is shown in figure 30.

DISEASES

Root rot.—The factor which has most limited vanilla production in Puerto Rico is a root rot disease. Reference to the disease was first made in Puerto Rico by H. E. Thomas (*22*) of this station. In 1922 McClelland recorded considerable damage to vanilla by apparently the same disease, which had become such a problem that experimental work with vanilla was temporarily abandoned at Mayaguez. McClelland reported to growers that vanilla should be considered only a temporary crop because of this root rot disease. In 1922 C. M. Tucker, station pathologist, undertook a study of the causal organism, and in

FIGURE 45.—Poison bait for slugs and snails is prepared by mixing corn meal with metaldehyde, then calcium arsenate, and finally with ground grapefruit. The bait should be applied immediately in late afternoon, since slugs and snails work mostly at night.

1927 described it as *Fusarium batatatis* var. *vanillae* Tucker (*23*). In a survey made by the authors in 1945 the growers reported an average of 40- to 50-percent infection of root rot, which is the chief reason why several growers recently abandoned their plantations. The disease is not confined solely to Puerto Rico, since the literature contains references to a similar root rot in other countries.

In the early stage of the disease there is first a browning and death of the underground roots and later of the aerial roots. With destruction of the roots, the plant ceases shoot growth and begins to send out numerous aerial roots, many of which die before or after coming in contact with the soil. The stems and leaves become flaccid, turn to a yellowsh green, and the stems begin to shrivel as their reserves and

water are depleted. Eventually the plant is a drooping, light brown, completely dried specimen (fig. 48). The symptoms usually do not appear before fruit production, which indicates that fruiting may weaken the plant and aggravate the disease.

It is recognized by vanilla growers that careful continuous attention and the use of the best cultural practices for vanilla result in definitely less trouble from the root rot disease. Observations at this station and in the commercial vanilleries indicate that the plants seem to become less capable of resisting the disease when weakened by drought conditions, by lack of important nutrients, too much sun, and/or over-

FIGURE 46.—Many growers claim that chickens are their worst pest in vanilla. They tear apart and expose the delicate roots to drying. A fence around the vanillery is the best protection against them.

pollination, and fruit production. Undoubtedly, much of the root rot of vanilla which appeared during World War II was due to overpollination by the growers to take advantage of good prices. It is interesting to note, however, that when prices are high some growers are of the opinion that it is possible to obtain profitable returns from vanilla in spite of a 20- to 30-percent root rot infection.

To control the disease the plants should be kept in a vigorous condition by maintenance of adequate shade and a heavy mulch especially at the beginning and during the dry season, by performing moderate to light pollination, and, where possible, by providing irrigation during extended dry periods.

Blast (mildew or añublo) disease.—The blast or mildew disease was first reported (*8*) in Puerto Rico near Villalba in 1939 and subsequently has been seen in many vanilleries. The symptoms usually are evident in the early development of the flower clusters but it is not uncommon for them to appear later while the vanilla pods are developing. The soft dark brown rotting usually begins at the stem end and extends toward the apical end, or, it may develop in the reverse manner. Many of the beans drop, leaving the bare inflorescence axis (fig. 49). According to observations at this station, the disease is favored

FIGURE 47.—Injury on the three beans to the right was caused by lizards climbing over the immature beans. The scratches lower the grade of the beans.

by heavily shaded humid areas where the beans remain moist almost continually. Pruning to admit proper light and air circulation is recommended for control. If serious, a bordeaux mixture can be used as a spray with 3 pounds of copper sulphate, 4 pounds of hydrated lime, and 50 gallons of water.

A similar disease has been reported in other countries, including Madagascar, Réunion, Haiti, and Mexico. G. Bouriquet (*3*), of Madagascar, maintains that this, or a similar disease, is caused by *Phtophthora jatrophae* Jens. This organism attacks also *Jatropha curcas* L., a vanilla support tree commonly used in Madagascar and Réunion.

FIGURE 48.—Root rot (*Fusarium batatatis* var. *vanillae* Tucker) is one of the chief limiting factors in vanilla growing in Puerto Rico. The rot most frequently appears after the third to the fourth years. The leaves and vines become yellow, flaccid, and eventually dry as a result of the initial death of the root system.

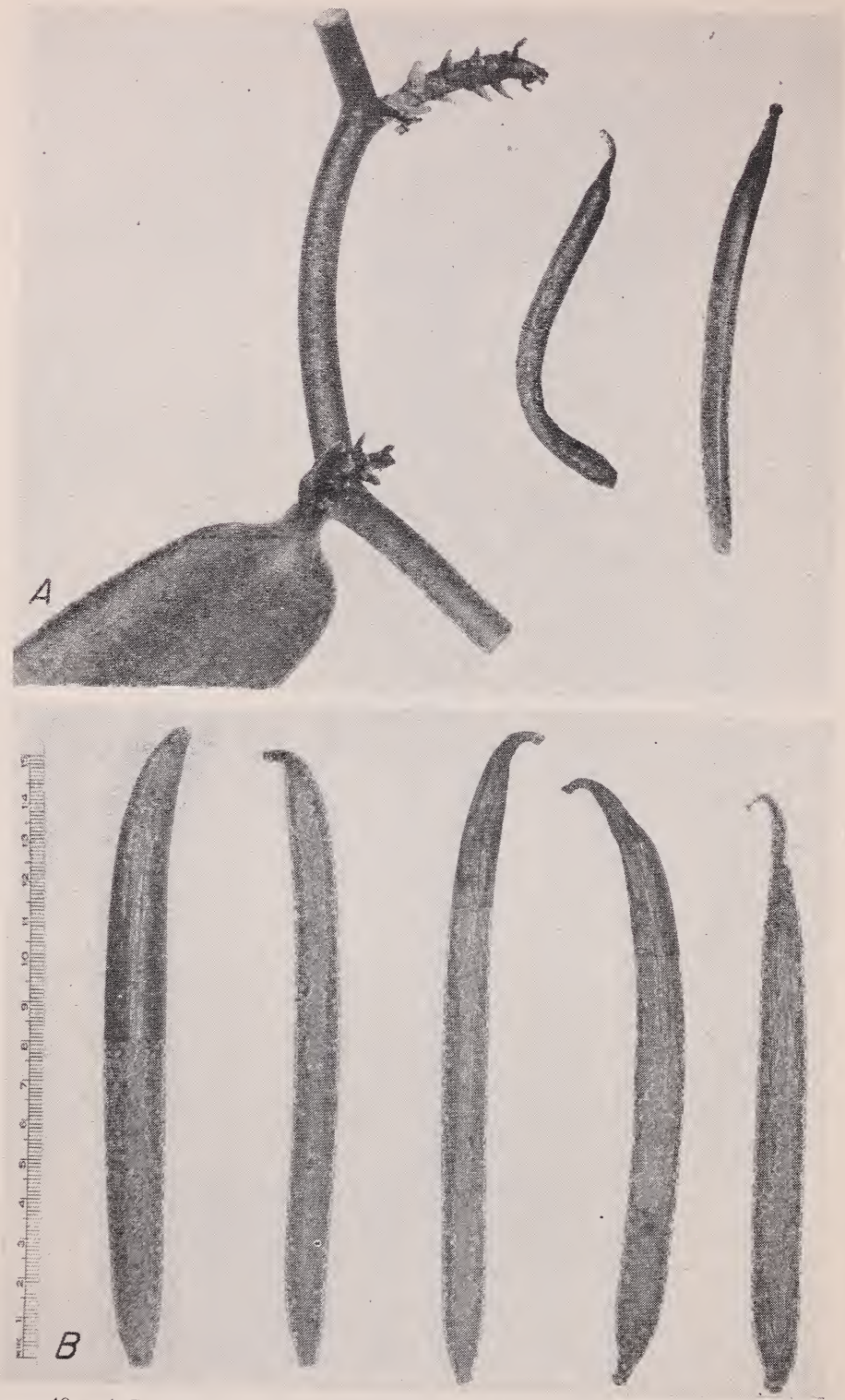

FIGURE 49.—*A*, Portion of the stem of *Vanilla fragrans* with diseased peduncles and two pods showing fruit rot. The disease is more prevalent where air circulation is poor and the beans remain wet much of the time. *B*, Various degrees of fruit rot. Rot may start at either end of the bean or appear in spots; eventually the entire bean may turn brown and drop.

Sunburn.—This condition, the effects of which are illustrated in figure 30, is brought about by a rather prolonged exposure of the vine to direct sunlight. According to Meinecke (*13*), when only a part of the vine is over-exposed, the organs involved lose their dark green color, turn yellow, and swell along the affected area. This swelling is due to the abnormal growth or "callousing" by the layer of cells underlining the dead epidermis. Eventually the tissues die and crack, affording opportunity for disease organisms to enter. The injury is more pronounced during the low-humidity dry season. Special care is needed during this period to provide about 50 percent shade.

Tip dieback.—This disease appears to be due to water deficiency since it occurs chiefly during the dry months (fig. 50.) The disease

FIGURE 50.—"Die-back" of the tips of vanilla vines (center) may occur during the dry season, after which the tips regenerate with the advent of the rainy season, as shown on the right. Heavy mulching before the dry season and irrigation when needed should help in preventing this injury.

affects the last two or three terminal nodes of the growing tip. At first, growth is checked; afterwards the whole region becomes brittle, brown, and shriveled. Irrigation during the dry season, if feasible, should assist in reducing injury.

Leaf spot.—Recently a leaf spot disease, characterized by the formation of corky raised areas over the leaf (fig. 51), has been observed on vanilla in Puerto Rico. Small areas coalesce to form larger ones. The disease so far is of minor concern.

COST OF GROWING VANILLA

The expense of planting and growing vanilla has varied considerably from one period to the next in Puerto Rico. The data given in the tabulations on pages 65, 66–67 are presented only as a guide to the prospective vanilla grower in estimating the cost of establishing and operating a vanillery. Net returns, obviously, will depend upon the current cost of materials and labor, the quality of the management,

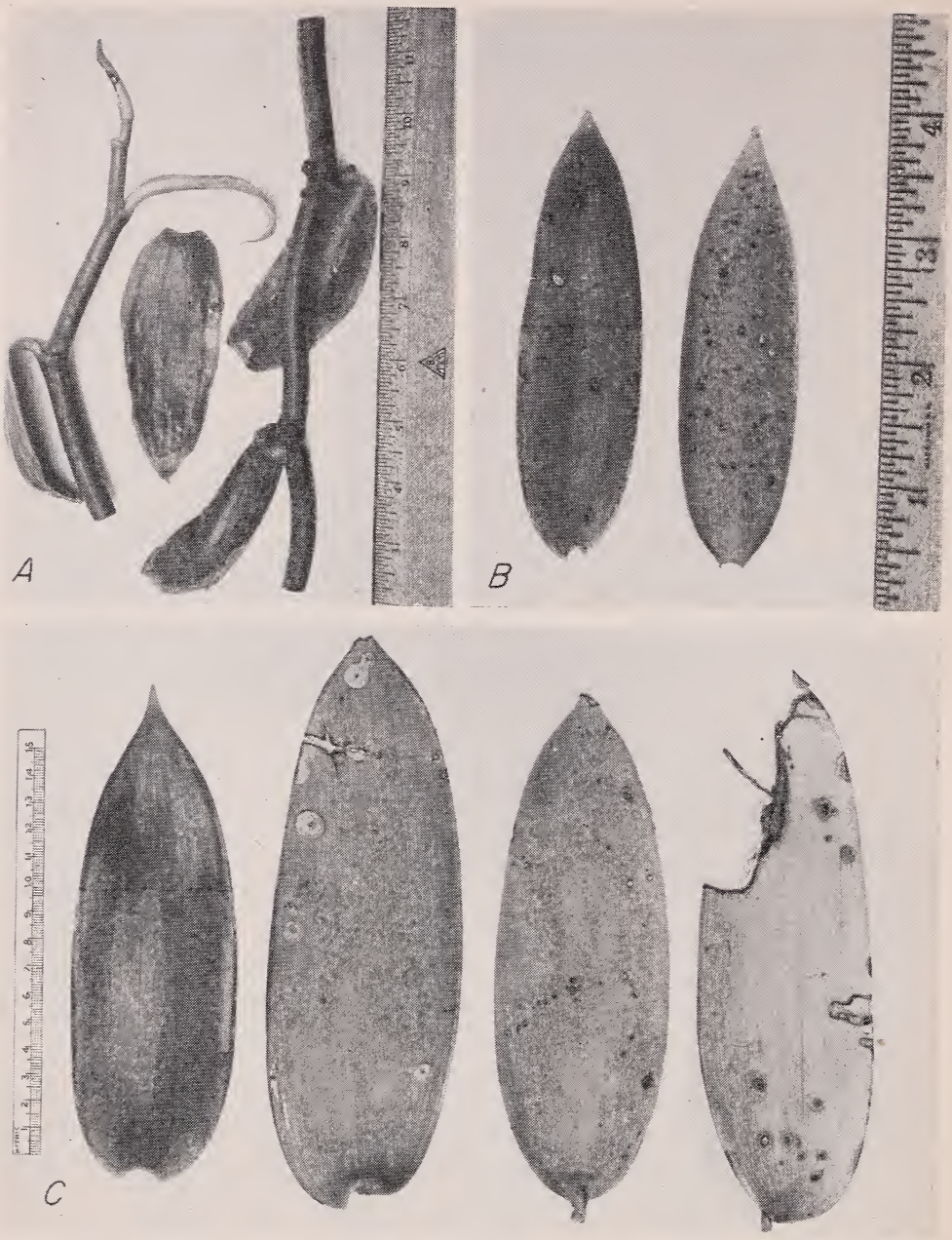

FIGURE 51.—The injuries to vanilla plant here shown are of minor concern except for the snail injury shown on the lower right-hand leaf in *C*. *A*, This unidentified injury has a mottled mosaic appearance. Note curling and corrugation of leaves. *B*, Gall-like protuberances on the surface appeared to be due to insect damage. *C*, An unidentified leaf spot of second, third, and fourth leaves with concentric rings was found on a vanilla plant near Morovis; healthy leaf on the left.

and the price of the beans. In the past 10 years the cost of labor, as indicated in the tabulations, has increased about 100 percent. It will be noted also that the greater portion of the cost of establishing and operating a vanillery can be abscribed to labor, which amounts to about 60 percent of the total. Labor in the mountainous regions of Puerto Rico usually has been 50 to 75 cents less per day than in the

lowland sugar regions; also, the quality of labor in general has been somewhat better in the hills.

Figures taken from the files of Vives Bazán (*16*) at Utuado show the cost of establishing and managing one acre of vanilla over a period of 7 years, preceding 1935. Mr. Bazán considers 7 years as the normal life of a vanillery in his region. A small crop can be harvested the third year following planting, after which about 3 full crops can be obtained before the vanilla is removed. The total cost of establishing, operating, and selling the product from an acre of vanilla over a period of 7 years was $312.51 or a cost per pound of about $0.625 for cured beans. Assuming that the cured vanilla was bringing a little over $2 a pound on the New York market, the net profit would be around $700, or an average of about $100 net per acre per year over the 7-year period.

The items of cost of cultivation, processing, and transportation of vanilla from 1 acre during 7 years, 1928 to 1934, inclusive, from the farm of Vives Bazán, Adjuntas, P. R., based on a total yield of 500 pounds of cured beans, are shown as follows:

	Dollars
Materials:[1]	
1,166 bucare slips for support trees at 1 cent	$11.66
1,278 vanilla slips at 3 cents	38.34
	50.00
Clearing: 80 man-hours at 6¼ cents	5.00
Planting:	
Alignment: 64 man-hours at 6¼ cents	4.00
Terracing: 384 man-hours at 3¼ cents	24.00
Making holes: 64 man-hours at 6¼ cents	4.00
Planting bucare slips: 64 man-hours at 6¼ cents	4.00
Planting vanilla slips: 80 man-hours at 6¼ cents	5.00
	41.00
Cultivation:	
3 weedings per year (7 years) at $3 per weeding	63.00
Pollinating 5 cwt. at $9 per hundredweight	45.00
Pruning bucare and arranging vines: 16 man-hours per pruning and arrangement; 4 per year for 5 years at 6¼ cents per man-hour	20.00
	128.00
Harvesting: 5 cwt. at $1 per hundredweight	5.00
Curing: 5 cwt. at $6 per hundredweight	30.00
Depreciation of curing equipment[2]	2.11
Depreciation and maintenance of curing plant	2.22
Containers	12.94
Transportation: 5 cwt. of vanilla shipped from the farm in Puerto Rico to New York through P. R. Express Co., at $3 per hundredweight	15.00
Taxes: Value of land $65.00—tax rate $2 on $100 per year. For 7 years	9.10
Workmen's compensation	12.14
	88.51
Total cost of 500 pounds	312.51
Cost per pound	0.625

[1] Allowance has been made for necessary replanting, approximately 20 percent for vanilla, and 10 percent for bucare.

[2] If desired, more detailed information on costs of establishing and operating a private curing plant may be obtained elsewhere (*16*).

In the more recent data obtained from Graciano Archilla at Morovis, presented in tabulation below, the net profit per year per acre over a 7-year period ending in 1945 was $119.78. Although cured vanilla beans were selling for almost three times as much in 1946 as in 1935, the increased labor and materials costs during the latter period minimized the profits. The figures include also the cost of supervising the vanillery by Mr. Archilla, amounting to about $500 over the 7-year period. This cost was not included in the figures for the vanillery at Utuado and, therefore, the data are not strictly comparable. Also, the cost of curing, packing, and shipping to the continental market was not included in Mr. Archilla's data because of the fact that his vanilla was mailed immediately after harvest to the cooperative curing plant of which he is a member. The cost of curing, packing, and selling beans for members of the Castañer curing plant in 1943–44 and 1944–45 was $0.201 and $0.293 per pound of green beans, respectively. The ratio of pounds of green beans required to make 1 pound of cured beans at the Castañer curing plant varied between 4.55 to 1 and 4.85 to 1.

The items of cost of planting, cultivation, and transportation of vanilla produced on 1 cuerda (0.97 acre) during 7 years, 1938–45 inclusive,[1] at the farm of Graciano Archilla at Morovis, P. R., are shown as follows:

	Dollars
Materials:	
2,400 bucare slips at 0.03 [2]	72. 00
2,400 vanilla slips (8 internodes) at 0.06 cents [2]	144. 00
Packing material (used store cardboard cartons and string)	3. 00
Total	219. 00
Labor:	
Cleaning land, 80 man-hours at 0.12 cents [3]	9. 60
Alignment, 32 man-hours at 0.12 cents	3. 84
Terracing, 112 man-hours at 0.12 cents	13. 44
Making holes, 160 man-hours at 12 cents	19. 20
Planting bucare slips, 32 man-hours at 12 cents	3. 84
Planting vanilla slips, 128 man-hours at 0.12 cents	15. 36
Cultivation: 2 weedings per year, or 14 weedings in all at 48 man-hours—672 man-hours at 0.12 cents	80. 64
Pollinating, 12 cwt., 320 man-hours per flowering season—1,280 man-hours at 0.12 cents	153. 60
Harvesting—480 man-hours (120 hours per season) at 0.12 cents [4]	57. 60
Pruning, once yearly, 128 man-hours at 0.12 cents	15. 36
Mulching, 32 man-hours at 0.12 cents	3. 84
Supervising by owner, 280 man-days (40 man-days per year at 20 cents per hour)	448. 00
Total	824. 32

[1] With good management a vanillery may bear 9 years or more.

[2] Four bucare and 4 vanilla slips are planted at each "hill"; under this method it is claimed that a larger yield is obtained sooner for a given area than with other methods.

[3] In addition, laborers get breadfruit and other native food on the owner's farm. Owner may build houses for laborers to live in, or furnish part of materials. (House value—$25–$50).

[4] Harvesting includes hauling of crop from plantation to post office.

	Dollars
Miscellaneous:	
Postage, 1,200 lbs. at 0.035 per pound (insured)	42. 00
Workmen's compensation	8. 00
Taxes, assessed value of land—$60 per acre. Tax rate $2.16 per semester (6 months) on each $100 assessed value for 7 years	18. 20
Total	68. 20
Total cost	[5] 1, 111. 52
Income—12 cwt. of green vanilla pods, or 3 cwt. of cured pods at $650 per hundredweight	1, 950. 00
Net income in 7 years	838. 48
Net income in 1 year	119. 78

[5] Yields are estimated low, labor costs high, and price received for beans relatively low for war year 1945.

CURING

Over 95 percent of the Puerto Rican vanilla crop is cured at the plant of the vanilla growers' cooperative at Castañer (figs. 52 and 53) where a uniform quality pack is prepared for the United States market. In 1946 there were about 150 members of the cooperative. The mem-

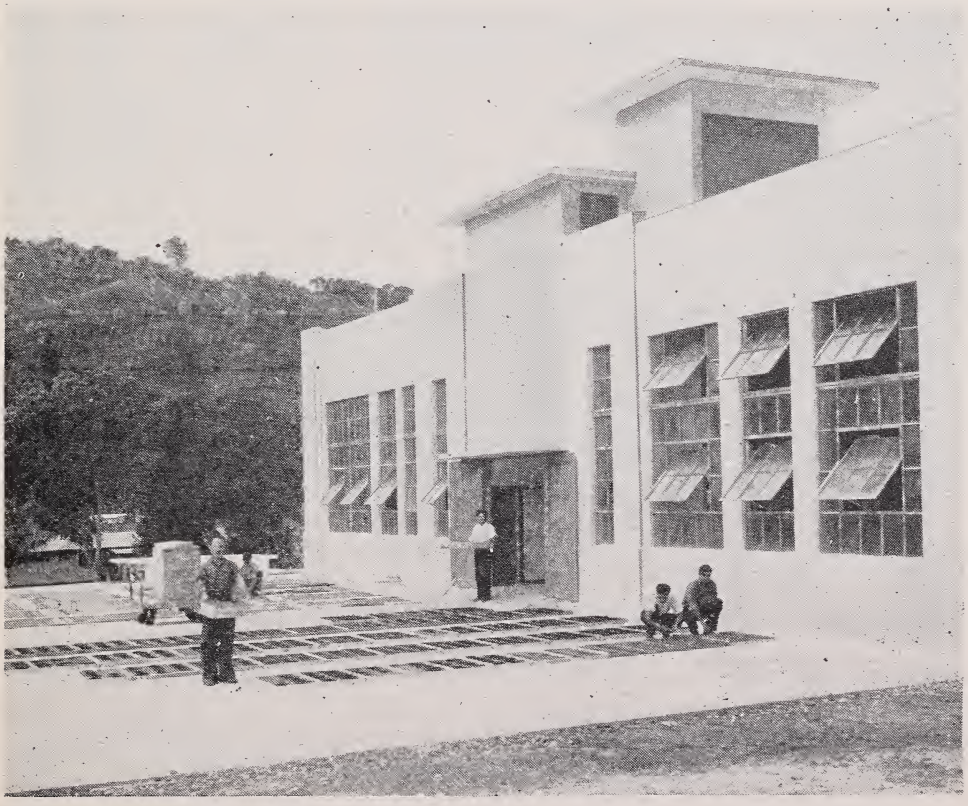

FIGURE 52.—A large open concrete floor was constructed on the south side of the Castañer curing plant for the purpose of sunning the beans during the curing process. The concrete floor and walls are preferably white to reflect heat of the sun.

bers sign a 6-year agreement to sell their entire vanilla output to the cooperative. Nonmembers also are permitted to send beans to the plant for processing, but they pay a special service charge which may vary according to assignment by the board of directors. In 1945 this service charge was 15 cents per pound of green beans. The growers send beans in lots by insured mail immediately after picking. The green beans are classified on arrival into "Primes," "Seconds," and "Splits," and an account is opened in the books for the respective grower. An official receipt and detailed description is sent to the

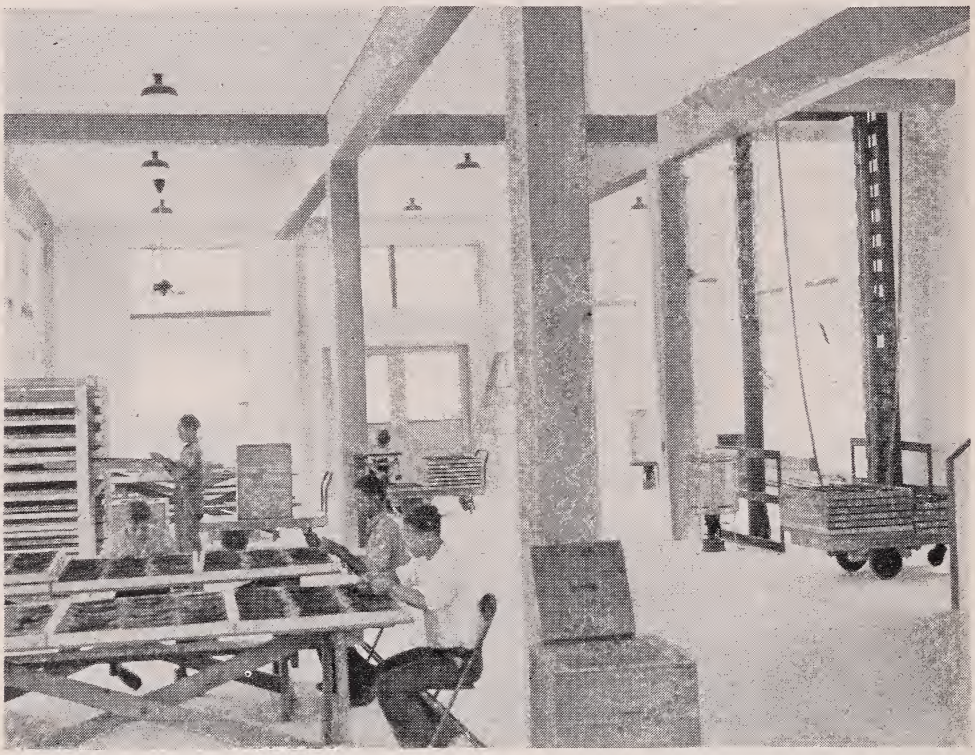

FIGURE 53.—Curing equipment inside the Castañer plant. Hot-water dipping containers are shown at the right center for killing the beans. On the left, after having been "sweated" the beans are being straightened and sorted according to size, after which they are placed in the drying racks to the left. When they have reached about 27 percent moisture, they are tied in bundles and placed in the conditioning boxes, one of which is shown in the foreground.

grower for each lot. The aggregate of lots from members and nonmembers is then cured together as one lot, and after the curing process is completed, usually in June or July, samples are sent to the United States via a broker in New York to be placed before bidders. A vanilla sales committee of the cooperative approves the sale to the highest bidder. The beans are then packed in wax paper and especially prepared cartons (fig. 54) and shipped six to a case by classification and size.

A discount is made on operation costs, selling costs, and reserves for the cooperative,[11] plus any advance money given to members. The

[11] In 1943–44 the discount was 23 cents per pound of green beans; in 1944–45 it was 28 cents.

cooperative is allowed to advance to members 50 cents per pound of green beans received at the Plant. Nonmembers do not have this privilege. In 1944–45, $42,000 worth of cured beans were sold to a firm in Philadelphia, who paid $7.50 per pound of cured beans, "heads and tails," with 9 percent "cuts" included.

Steps in curing.—The curing process should begin within about 7 days after the beans are harvested. In Puerto Rico curing operations begin in September and extend to about May. The curing process consists of essentially four steps: (1) Heating or freezing the beans

FIGURE 54.—When tin is scarce, corrugated boxes are used by the cooperative in Puerto Rico for f. o. b. shipment of cured beans to Philadelphia. Six of these containers are packed in a special wooden box. The wax paper around each bundle and lining the box reduces drying of beans and the spread of mold and mites.

to kill the tissues and stop life processes; (2) "sweating" the beans by drying slowly in sun or oven heat until they are flexible; (3) slow drying, usually at room temeprature until the beans have lost from 70 to 75 percent of their moisture; and (4) conditioning the beans within closed boxes at room temperature until they develop the characteristic fragrance.

There are several methods of killing the green vanilla. They are: (1) Sun killing; (2) oven killing; (3) hot-water killing; (4) killing by scratching; and (5) killing by freezing. The first three methods

are probably of more interest to Puerto Rican growers and are briefly described.[12]

Sun killing.—This method is extensively used in Mexico. The steps are as follows: (1) Sort beans according to maturity and size, (at the Castañer plant they are sorted into 3 lots: (*a*) Primes—whole sound beans 5 inches or more in length, (*b*) Seconds—whole beans less than 5 inches in length, and (*c*) Splits—any length bean that has started to split); (2) wipe darkening or browning beans with castor oil and cure separately; (3) place beans on dark woolen blankets, spread over racks, and subject to sun; (4) place thick ends of beans toward center of blanket, roll the blanket, place in sweating box lined with blankets, and move to building; (5) next day remove beans still green, oven, treat, cure separately; (6) expose beans to sun for about 17 days from 1 to 2 hours in hottest part of day, as described under (4); (7) place beans in sweating box every fourth or fifth night, leave open on racks other nights; and (8) straighten the beans, wrap them in bundles of 50, tie with tough black wax string, wrap in oiled paper, and place in oil-paper-lined boxes for several months for conditioning and the development of aroma.

Oven killing.—To kill beans by the oven method: (1) Tie beans in bundles of 100 to 500, roll in blankets; (2) place in oven at 60° C. for 36 to 48 hours; (3) place in sweating boxes for 24 hours; and (4) proceed as described under (6), (7), and (8) above.

Hot-water killing.—This method is used at the cooperative curing plant in Puerto Rico: (1) Place beans in wire basket (fig. 55) and immerse in hot-water bath (178° F.) for 30 seconds, take out basket for 10 seconds, immerse again for 30 seconds, take out for 10 seconds, immerse again for 30 seconds; (2) drain beans and wrap in woolen khaki blanket and put into sweating box overnight; (3) repeat process next day with only two dippings at 160° F., wrap in blanket, put into sweating box overnight; (4) repeat process next day with only one dipping at 150° F., wrap in blanket, and put into sweating box overnight, and (5) next day bring to sun for 2 hours and put again in sweating boxes, repeating this last procedure for about 7 days until ready for air-drying in plant racks, etc. Splits are immersed only the first day, with the rest of the procedure the same.

When sun heat is not sufficient to dry the vanilla, ventillated oven-driers may be employed at a temperature of 45° to 50° C. (fig. 56). In fact, if sufficient space is available in such ovens, there is an advantage in using the oven instead of sun because it requires less work, takes less time for sweating and drying, and reduces the likelihood of subsequent mold development. The quality of oven-cured beans is considered comparable with sun-cured beans.

Cut beans or "cuts"

Damaged, overripe, or undersized beans (5 inches or less) found during the harvesting and curing process are classified as "cuts." These beans are cut into sections 1 inch long after all curing is done. Culling of beans less than 5 inches in length, or beans that are completely split, is done while curing is in progress. These beans are set

[12] For a more detailed description of these and other curing methods the reader is referred to references *1* and *2*.

aside in marked trunks until ready for cutting. Buyers dealing with the cooperative curing plant have requested that the cuts not exceed 10 percent of the crop. In Mexico the small curers or producers who do not have the necessary equipment to cure whole beans may cut their entire crop (*10*).

Between 10 and 20 percent of the crop in Mexico usually is marketed under the classification of cuts. During periods when high prices are being paid for vanilla beans, as during World War II, Mexico some-

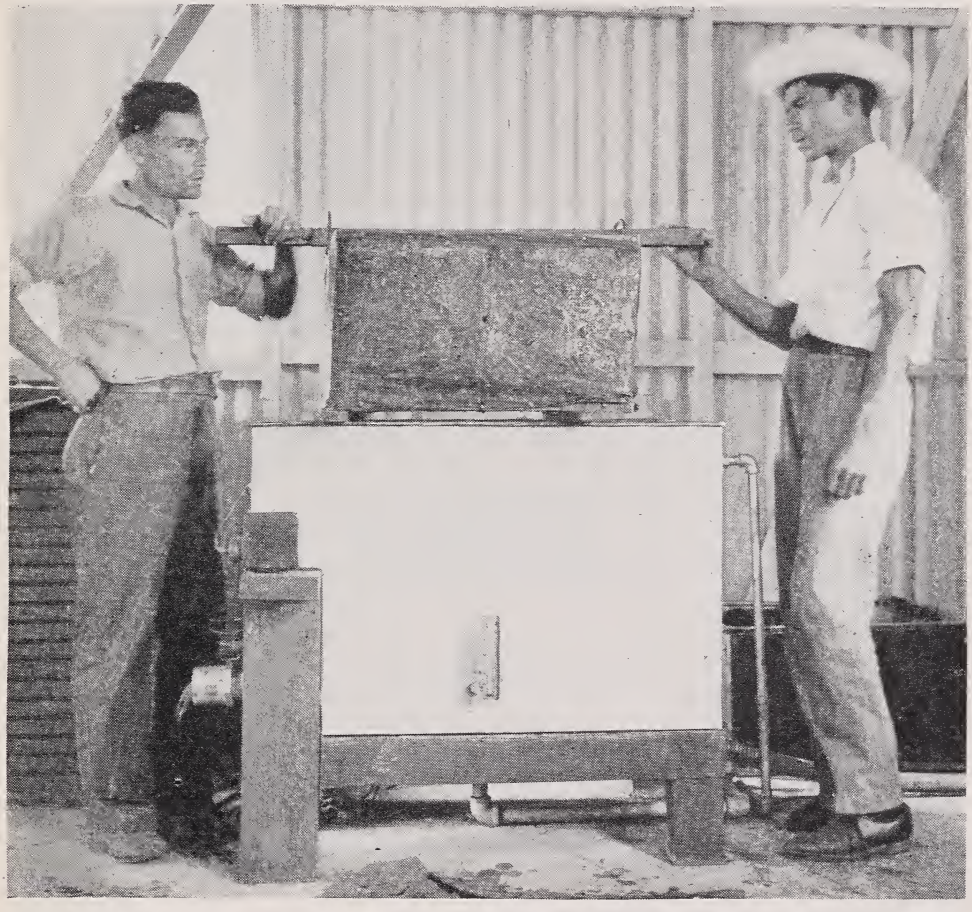

FIGURE 55.—A thermostatically heated water bath is used for killing green vanilla beans at the Castañer plant. Beans are placed in a copper screen container, dipped, rolled in heavy woolen blankets, and placed in boxes to start the curing.

times sold as much as 50 percent of the total crop as cuts because they have faster curing properties and could meet an early market demand. Generally the prices paid for cuts are considerably below those paid for whole beans, but during high-price periods the spread between the two prices is much less. Experiments at this station have shown that there is no difference in quality between cut and whole beans, especially when the cuts consist largely of split beans. Split beans have had opportunity to fully mature on the vine and, in fact, may contain more aroma than the green beans. However, the present market is adjusted to handle and pay a premium for the whole beans, splits and cuts usually bringing a much lower price.

FIGURE 56.—The curing oven at the Castañer curing plant is employed on cloudy days or during rush periods. Heating coils and water tanks are located on the floor; small ventilation holes are near the floor level and in the ceiling.

GRADING AND PACKING

The care used in grading vanilla beans depends upon the market demand, the general quality of the crop, and the specifications laid down by the buyer. When the general price level is high, less care is used in grading. If the price level is low, the top grades tend to be very good. Cured whole beans and cuts for exportation are usually classified into five grades at the cooperative curing plant in Puerto Rico as follows: (1) Primes—whole straight beans 5 inches or more

in length with no scars or visible permanent marks; (2) seconds—whole straight beans 5 inches or more in length with simple small scars; (3) thirds—whole crooked beans 5 inches or more in length with many visible scars; (4) splits—beans over 5 inches in size which show splitting, and (5) cuts—beans less than 5 inches in length, or any size bean which is not whole.

These beans are then laid out in rows as shown in figure 52 on screen frames. Each group is sorted and packed in bundles of 50 to 70 beans with the stem ends placed together, as shown in figure 57. Strong black wax string is used to tie the bundles.

During the curing process the beans are almost automatically graded because the better beans usually require longer curing. The more skilled and careful workmen are employed to sort the beans and bundle and tie them. About 40 bundles are placed in each Mexican tin and a less number in the fiberboard box shown in figure 54. These are left open for examination by the buyers and custom inspectors. Waxed paper is used to line the containers. The tins or cartons are then placed in wooden boxes for shipment.

FIGURE 57.—A bundle of 60 Puerto Rican vanilla beans ready for market. The beans are bound with a tough wax string.

Moldiness and spoilage

One of the chief reasons for reducing the moisture content in the beans during curing is to reduce the danger of molds and spoilage during shipment and storage. Moldy beans naturally bring a lower market price. There are two kinds of molds. One is white at first and turns green later; the other is black and spreads rapidly. The mold enters at the stem end of the beans. Sources of infection are dirty blankets, contaminated containers, and packers who place the strings in their mouths while packing the bundles. Sterilization of the equipment by boiling in water and sterilization of the wool blankets in antiseptic solutions[13] should be practiced as preventive measures. If the attack of mold is severe, the entire room may need to be painted and disinfected with a 1 to 1,000 solution of formaldehyde.

The beans should be examined once a week during conditioning and storage to detect moldiness. If molds are spotty, the areas can be daubbed with cotton soaked in 95-percent alcohol.

Infestation by the American mushroom mite (*Tyrophagus* (formerly *Tyroglyphes lintneri* (Obs.)) is sometimes troublesome; its presence imparts a bad odor to the beans. Mites may appear during

[13] Woolen blankets should not be boiled; they may shrink to half size.

the conditioning stage or in shipment and subsequent storage. In cases of limited infestation, they can be treated with alcohol or by sunning. Mites can be controlled by fumigating the curing and conditioning equipment and the entire room with sulfur. This is done by burning flowers of sulfur or sulfur candles in a closed room or under tarpaulins. If the mites appear during shipment or after the beans have arrived at the market, it may be necessary to cut the beans and market them as "cuts." Mallory and Cochran (*10*) report a "cheesy" substance which may develop on the beans during or after conditioning. This is thought to be a ferment of the oleoresins which tends to attract the mites.

In 1937–38 the American Can Co. canned some cured vanilla by vacuum pack. This preliminary work in the preservation of vanilla against molds and mites during shipment and storage showed some promise.

GENERAL MARKETING PROCEDURE

In Puerto Rico the marketing procedure, as outlined previously under "Curing," is relatively simple for the majority of the growers. However, the cooperative curing plant in Puerto Rico might well carry its program one step further and manufacture pure vanilla extract from their beans. Alcohol and sugar, two needed ingredients, are available in abundant quantities and at relatively low cost. However, any change in present handling and marketing procedures would place the cooperative in direct competition with private concerns manufacturing vanilla extracts. A stable and reliable product would be the first requisite to be satisfied and this must be backed by a sales program that would maintain a steady market for the product. If these problems could be solved, the net return to the individual Puerto Rican grower should be greater.

In Mexico (*10*) and other countries where total vanilla production is relatively large, and there is no centralized marketing agency, the marketing procedure is somewhat more complicated than in Puerto Rico. The producer may sell his beans in one of several ways. The larger portion of the crop, perhaps 50 percent, is sold to traveling buyers, who usually work on a commission basis, and who are representatives of the curers. The buyer goes by pack train carrying silver in boxes which he trades for green beans. Competition is keen among these buyers when prices are high. A second means by which beans are sold is direct from producer to curer. The producer brings his beans to town to bargain personally with the curer and naturally he makes a somewhat better profit by bypassing the field buyers. The curer may cure beans solely and send them to a large curer-exporter. Or, the curer-exporter may buy the beans direct from the grower and then deal either with one of the 10 to 15 large buyers in the United States, or with commission men in the United States who in turn sell to the large buyers. The buyers in the United States open each box of beans (fig. 58), inspect the quality, check the weight to determine the amount lost in shipment, sort the beans, and repack them according to the grade desired by specific manufacturers.

Vanilla buyers are essentially speculators and may take considerable risk in handling the beans. They are keenly interested from one

year to the next in the world production of vanilla because the price they quote to the exporters, curers, or to the producers depends almost entirely upon how well the market is supplied with vanilla beans. If, according to their best judgment, the world supply will be small to average, and they, therefore, pay or advance a relatively high price for the beans, and at the last minute a large shipment of beans arrives from an unexpected source, the price naturally will decline and the buyer may be left "holding the bag." In order to gain an advance estimate of the world vanilla supply the larger United States buyers may hire special representatives who can mix with the native people and talk their language. These representatives visit the growers in order to gain some idea of the size of the vanilla crop and thus enable

FIG. 58.—In a Philadelphia dealer's warehouse the imported beans are opened, weighed, checked for quality, and regraded and repacked, if necessary, according to the desires of individual clients. (Courtesy M. Cortizas and Co., Philadelphia.)

their home company to set a price that is likely to bring a reasonable profit.

Under the present over-all marketing system it is evident that the buyers who deal directly with the growers are a necessary part of the procedure of getting the beans from far-off sources to the consuming public. The vanilla marketing busines, however, like the marketing of many other tropical crops, could conceivably undergo more streamlining in future years.

RECOMMENDATIONS

1. Vanilla is an orchid which grows and fruits best under relatively uniform conditions of shade, soil moisture supply, and an average temperature of between 75° and 80° F. The best vanilla sites are usually located on the lower one-third of a concave slope where there is protection from wind and high temperatures, and the soil moisture and fertility conditions are more favorable. Vanilla should not be planted on exposed high slopes.

2. Under natural conditions, vanilla appears to grow best in those sections of Puerto Rico where the rainfall is about 75 inches or more per year and fairly well distributed from one month to the next. In Puerto Rico vanilla has been grown most successfully in the region of Morovis.

3. Vanilla must be supplied with abundant mulch to a depth of at least 12 inches, and this depth must be maintained especially during the dry season which usually begins in October or November.

4. Vanilla appears to grow and fruit best under shade admitting from one-third to one-half full sunlight. This shade should be maintained as uniform as possible throughout the year, especially during the dry season when it is needed most.

5. Vanilla should not be overpollinated. Until more evidence is available, not more than five to six flowers per cluster should be pollinated. Fruiting creates a heavy drain on the vine; when excessive it may eventually cause premature death.

6. Difficulties with root rot and death of vines can be considerably reduced by moderate to light pollination, the maintenance of uniform shade throughout the year, and the application of abundant mulch material to the roots, especially during the dry season. Irrigation is desirable during extended dry periods of more than 5 or 6 weeks.

7. Dwarf bucare has been used for a support tree in Puerto Rico, but there is definite need for a low-branching semidwarf, small-leaf support tree which does not lose its leaves during the dry season. The cashew nut tree has shown promise as a vanilla support at Mayaguez. The combination of the tall *Inga vera*, largely for shade, and the dwarf bucare for support also appears desirable.

8. Some of the most successful vanilla in Puerto Rico has been grown under uniform shade of ½ to ⅓ full sunlight provided by a bamboo lath house at Mayaguez, as shown on the front cover of this circular. This intensive method of growing vanilla shows commercial promise in Puerto Rico.

9. Vanilla will produce a small crop the third year after planting, but the first full crop cannot be harvested until the fourth or fifth year. From three to five crops have been obtained in Puerto Rico before the vanilla is removed. A new area of vanilla should be planted every second or third year in order to insure continuous crops for the grower.

10. The central cooperative vanilla curing plant at Castañer, Puerto Rico, provides an excellent curing and marketing channel for Puerto Rican vanilla. The uniformly cured and packed product tends to develop confidence among buyers.

11. It appears that there will always be a demand for pure vanilla because it is generally accepted among buyers and users that, as yet, synthetic vanillin is not comparable in quality or aroma.

12. The value of the world crop of vanilla is around $10,000,000 a year. Vanilla cannot be expected to be more than a minor agricultural crop in Puerto Rico unless some unforeseen advancement is made in growing technique for the crop.

13. Vanilla is a good supplemental crop for the hill farmer to grow under a diversified crop system that would permit him to raise from time to time the crops that are in best demand.

14. Vanilla properly grown in Puerto Rico has produced an average profit of a little over $100 per year per acre over the approximate 7-year life of the planting. This profit could probably be increased by careful and judicious management, assuming that marketing conditions are relatively good.

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